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Economic Trends in Canadian Gold Supply

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ECONOMIC TRENDS IN CANADIAN GOLD SUPPLY

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FOREWORD

This paper represents research sponsored by the Centre for Resource Studies and aimed at improving the understanding of the conditions and issues facing the Canadian mineral industry, in order to assist in formulating policy decisions in industry and government. The Centre's working papers are offered for information and discussion, in an attempt to encourage feedback to the authors and additional research in mineral policy. Opinions presented are those of the authors, and do not necessarily represent the views of the Centre or its sponsors.

Margot J. Wojciechowski
Centre for Resource Studies

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SUMMARY

The study examines economic trends in Canadian gold supply, focusing on the 40-year period 1946-85. The following facets of supply are analyzed:

- the price of gold;
- Emergency Gold Mining Assistance (EGMA);
- several aspects of gold mine production;
- employment;
- mine operating costs;
- the changing mix of production from old mines, new mine developments, and new discoveries;
- investment in sustaining existing capacity, new productive capacity, and exploration for gold deposits;
- cash flow synthesis of gold mining revenues and costs.[1]

The big picture emerging from the analysis of these specific trends is that of a long, approximately 50-year, economic cycle. The long wave of prosperity and depression in gold supply, which is shown to be governed by the gold price, runs counter to the long business cycle which characterizes overall economic activity and other types of mining endeavour.

The Canadian trends analyzed in this paper are part of a worldwide phenomenon. An upward phase of the long wave, initiated in the midst of the great 1930s depression with the increase of the gold price to U.S. $35 per ounce, carried over in Canada into the immediate postwar years, the start of our study period. The number of producing gold mines peaked at 91 in 1948-49. Until 1952, gold retained its place as perennial leader in the value of all metals and mineral commodities produced in Canada.

Following the initial stimulus of $35-per-ounce gold, however, the fixed nominal price and cost inflation through the late 1940s, 1950s, and 1960s combined to force a steady decline in gold mining activity. While Canada generally experienced a long period of rapid and stable economic growth between 1950 and 1970, and the mineral sector otherwise flourished, gold mining was increasingly forced into a survival mode. The trends examined in the paper show both the actions that were taken to address the depressed conditions and the consequences which nevertheless followed.

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1. The paper restricts attention to the supply of gold from lode deposits. Lode gold mines accounted for 80 percent of the total amount of gold produced in Canada during the study period. The balance consists mainly of by-product gold from other metal mines, with a small amount recovered from placer deposits.

The actions taken were as follows:

- cut-off grades were systematically raised;
- production was concentrated in larger mining operations to realize cost economies;
- several higher-quality deposits were brought into production;
- little exploration was carried out and the development of ore reserves was cut back to the bare minimum;
- a major government subsidy program, EGMA, was implemented to ease the impact of mine closures on the dependent gold mining communities.

Nevertheless, the inescapable consequences of the cost-price squeeze continued, extending well into the 1970s:

- the number of operating gold mines fell from 91 in 1949 to a low of 17 in 1977;
- gold's ranking among metals in value of production had slipped from first to sixth place by 1968;
- Canadian lode gold production declined from 120 tonnes in 1952 to a low of 32 tonnes in 1980;
- employment in gold mining fell from 22,900 in 1947 to 4,600 in 1977.

The recovery of gold supply which has subsequently occurred was brought about by the establishment of a free commodity market for gold transactions in the late 1960s. The spectacular rise in gold prices which followed has provided a remarkable worldwide stimulus for gold mining similar to that which occurred in the 1930s; an industry which was depressed in the 1950s and 1960s has once again become the focus of investment and growth. This new upward phase of the long economic cycle which has taken approximately 15 years to build up to the record levels of investment taking place in the mid-1980s, more generally corresponds to a troubled time of economic recessions, high unemployment, and otherwise depressed mineral market conditions - further evidence of the counter-cyclical nature of gold mining.

In Canada, we are just starting to realize the results of the record levels of investment. The number of producing gold mines increased from 17 in 1977, to 43 in 1985. In 1987, gold is expected to return to first place among metals in value of production. Canadian lode gold production increased from 32 tonnes in 1980, to 69 tonnes in 1985, to an estimated 95 tonnes in 1987, while gold mine employment rose from 4,600 in 1977 to 7,900 in 1985.

At the time of writing (October 1987), we estimated that about $800 million per year was being expended on gold exploration in Canada, and about $1 billion was being invested during 1987 in the expansion of existing mine capacity and the development of 15 new gold operations. Several factors were fueling this unprecedented level of activity: the eagerness of investors to own gold mining assets; the flow-through share financing policy; the desire to employ available geoscience, engineering, consulting, and contracting skills; and the current spot price of over C$600 per ounce of gold.

It is clear that we are once again riding the crest of a wave of gold prosperity. But, how long will it last? In attempting to look ahead at what the future may hold for Canadian gold supply through the 1990s, to the turn of the century and beyond, it would be remiss not to reflect on the long historical economic wave which has carried us to our present euphoric state.

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1. INTRODUCTION

Setting

Until the postwar years, gold was the keystone of the Canadian mineral economy, a perennial leader in the value of all metals and mineral commodities produced. Then, from about 1950, gold mining fell on hard times. An increasing cost-price squeeze forced gold producers into a survival mode with inevitable consequences. These depressed conditions carried through into the 1970s. A spectacular rise in free market gold prices from the early 1970s provided a stimulus for the recovery of gold mining in Canada which by the mid-1980s has encouraged unprecedented levels of investment in gold exploration and development. This new wave of prosperity in Canadian gold supply is part of a worldwide phenomenon.

As a basis for corporate planning and government policy, we need to develop a better understanding of the economic environment for gold mining and the economic basis for investment in gold supply which will prevail to the turn of the century and beyond. In contemplating the uncertain future which lies ahead, it may be useful to examine the historical trends which have brought us to the present state of apparent good fortune.

Objective and Organization of Study

The objective of the study is to examine economic trends in Canadian gold supply, focusing on the 40-year period 1946-85. This historical perspective is intended to support the analysis of current policy and planning issues which concern the long-term prospects for gold mining.

The remainder of this chapter considers the changing role of gold supply in Canada. Chapter 2 examines trends in the price of gold, the most important determinant of supply trends. The federal government's historical involvement in providing Emergency Gold Mining Assistance (EGMA) is discussed in chapter 3. Chapter 4 examines several facets of gold mine production. These include trends in the number of producing mines, the size and grade of ore reserves, the rate of ore production, the ore grades mined, and the rate of gold production. Employment in gold mining is charted in chapter 5.

Chapter 6 looks at trends in mine operating costs. These include aggregate costs for the gold mining sector, as well as mine-specific unit costs per tonne of ore mined and per ounce of gold recovered. The changing mix of gold production is examined in chapter 7 from existing gold mines in production prior to 1946, from old discoveries brought into production during the 1946-85 period, and from gold deposits discovered during the study period. Chapter 8 analyzes investment trends in gold supply including repair, capital, and exploration expenditures. A cash flow synthesis of total revenues and total costs for Canadian gold supply during the 40-year study period is presented in chapter 9. In conclusion, an attempt is made in chapter 10 to place the specific trends examined into a broader, more general context.

Monetary values are expressed in constant 1985 Canadian dollars unless otherwise specified. Physical measures of gold supply are stated in metric units. A note on the units and definitions applied in the paper is given in appendix I. The economic trends examined in the study are, for the most part, graphically presented in the text. Appendix II provides the statistical tables from which these illustrations are drawn. Appendix III gives an illustrative example of the calculation of EGMA payments. The 169 lode gold mines included in the study data base are classified by dynamic component in appendix IV.

Gold's Position in the Canadian Mineral Economy

The 1946-85 timeframe includes several major events which deeply affected Canadian gold supply:

1946 - normal gold mining activities resumed after the interruption caused by World War II and the Lend-Lease Act;[2]

1948 - the commencement of the Emergency Gold Mining Assistance Act (EGMA);

1968 - the two-tier gold price system was established;[3]

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2. The Lend-Lease Act was passed by the U.S. Congress in March 1941 to allow Britain to borrow materials and supplies for the war on condition that they be eventually returned. This effectively eliminated the need for gold as a currency to settle international payments and gold mining lost its status as a strategic activity.
3. The official United States gold price, fixed at U.S. $35 per ounce since 1934, was thereby restricted to monetary transactions involving government-owned gold. An open market gold price free to fluctuate with supply and demand was recognized for commodity trading purposes.

1980 - the average annual gold price peaked at $996 per ounce;
1983 - the advent of flow-through share financing for mineral exploration;[4]
1985 - record levels of investment in gold exploration and the development of new gold mining capacity were reached.

Throughout the 1946-85 study period, Canada has maintained a rather distant third-place position in gold production behind South Africa and the USSR. Since Canadian production represents only 4-5 percent of total world supply, both individual Canadian gold mining companies and the entire domestic gold sector act as price takers under conditions of essentially perfect competition. Despite these factors, gold has made a major contribution to the development of the Canadian mineral economy.

Trends in the value of gold production are summarized in table 1. A total of 3,923 tonnes (about 126 million ounces) of gold valued at almost $29 billion was produced in Canada during the 1946-85 period. A maximum annual production of 144 tonnes (about 4.6 million ounces) was achieved in 1960. The annual value of gold production peaked at about $1.6 billion in 1980, in spite of the fact that physical output was at an all time low.

Until 1952, gold was the perennial leader in value of all metals (and mineral commodities) produced in Canada. By 1968, however, gold's ranking among metals had slipped to sixth place behind copper, nickel, iron ore, zinc, and silver (as shown in table 1). The late 1970s and early 1980s have seen a resurgence in the relative importance of gold production. Gold rose to third place in value of production during the 1982-85 interval. Preliminary figures for 1987 indicate that gold should regain the top position in value of production among metals.

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4. Flow-through shares were made possible through changes in tax legislation and since 1983 have evolved as an important source of equity financing for the Canadian mining industry. Flow-through shares may be defined as an interest acquired in a mining venture in which the tax deductions resulting from the expenditure of the invested funds are attributable (or "flow through") to the original investor on whose behalf the activity is undertaken. More specifically, under current Canadian tax laws, the tax deductions resulting from exploration activities can be attributed to the investor of equity funds in mining. See B.A. Kalymon, Flow-Through Share Financing, Working Paper No. 39, Centre for Resource Studies, June 1987.

Table 1

GOLD'S POSITION IN THE CANADIAN MINERAL ECONOMY

	GOLD PRODUCTION		VALUE OF GOLD PRODUCTION	
YEAR	AMOUNT (tonnes)	VALUE ($ 1985 million)	RANK AMONG METALS	PERCENT OF METALLIC MINERAL PRODUCTION
1946	88	777	1	36
1947	95	736	1	27
1948	110	755	1	25
1949	128	868	1	28
1950	138	967	1	27
1951	137	830	1	22
1952	139	754	1	21
1953	126	677	3	20
1954	136	732	3	19
1955	141	756	3	16
1956	136	702	4	13
1957	138	677	4	13
1958	142	697	4	14
1959	139	662	5	11
1960	144	682	5	11
1961	139	687	5	11
1962	130	667	5	10
1963	125	633	4	10
1964	119	592	5	9
1965	112	539	5	7
1966	103	474	5	6
1967	93	412	5	5
1968	85	365	6	4
1969	79	324	6	4
1970	75	284	6	3
1971	70	250	6	3
1972	65	357	5	4
1973	61	520	5	5
1974	53	625	5	5
1975	51	580	5	6
1976	53	406	6	4
1977	54	496	6	5
1978	54	650	6	7
1979	51	916	6	7
1980	51	1620	4	12
1981	52	1153	5	11
1982	65	1104	4	14
1983	74	1329	3	17
1984	84	1313	3	15
1985	88	1220	4	14
TOTAL	3923	25787		12 average

The position of gold in the Canadian mineral economy may be further illustrated by expressing the value of gold production as a percent of the total value of metallic mineral production. Gold's share, which averaged 12 percent for the 1946-85 period, is shown in table 1 to vary from a high of 36 percent in 1946 to a low of 3 percent in 1970-71, before recovering to 14 percent in 1985.

Gold may be produced from lode gold deposits, placer deposits, or recovered as a by-product from other metallic mineral deposits. Lode gold mines are associated with deposits in consolidated rock, typically quartz veins, from which gold is the prime contributor to value of production. Placer gold deposits, on the other hand, are surficial deposits formed by mechanical (usually alluvial) concentration of gold from weathered debris.

More specific trends in the amount and value of lode gold production, the focus of this paper, are presented in table 2. Over the study period, lode gold mines accounted for 80 percent of the total amount of gold mined in Canada, varying from 88 percent in 1947 to 63 percent in 1980. The balance of Canadian gold production comes from the other two sources. The most important of these is by-product gold recovered from copper, zinc, nickel, and other metal mines. A small amount of gold is also produced from placer deposits.

Table 2

LODE GOLD PRODUCTION IN CANADA

YEAR	AMOUNT (tonnes)	VALUE ($ 1985 million)	PERCENT OF TOTAL GOLD PRODUCTION
1946	74	653	84
1947	84	649	88
1948	96	659	87
1949	111	751	86
1950	117	819	85
1951	115	701	84
1952	119	645	86
1953	109	586	87
1954	116	627	86
1955	120	643	85
1956	115	593	85
1957	117	575	85
1958	122	599	86
1959	120	569	86
1960	122	579	85
1961	117	580	84
1962	109	557	83
1963	104	526	83
1964	98	487	82
1965	92	442	82
1966	84	388	82
1967	76	338	82
1968	69	297	81
1969	64	261	81
1970	60	226	79
1971	56	199	80
1972	50	278	78
1973	45	381	73
1974	38	453	72
1975	38	423	73
1976	38	296	73
1977	38	348	70
1978	36	438	67
1979	34	605	66
1980	32	1022	63
1981	36	795	69
1982	48	816	74
1983	56	1004	76
1984	65	1012	77
1985	70	980	80
TOTAL	3210	22800	80 average

2. PRICE OF GOLD

Overview

For over 100 years, the United States government fixed the dollar value of gold under various forms of gold standard.[5] In 1934, the U.S. government devalued the dollar by increasing the gold price from the $20.67-per-ounce price, which had prevailed since 1879, to $35 per ounce. Occurring in the midst of the great depression, this revaluation had a highly stimulating global effect on primary gold supply. Following the initial impetus, however, the fixed $35 nominal price combined with cost inflation through the late 1940s, 1950s, and 1960s to force a steady decline in gold mining activity. Most of the main producing countries, South Africa, Australia, and Canada, for example, introduced various forms of government assistance in an effort to maintain a viable industry and ease the impact of mine closures in dependent regions.[6]

During this era, the gold-backed U.S. dollar served as a worldwide medium of exchange and stabilized international currencies. By the 1960s, however, several factors - balance-of-payments deficits, the increasing importance of the U.S. dollar as an international reserve, inflation, and mounting federal debt - reduced the world's confidence in the ability of the U.S.A. to redeem its currency and debt in gold. United States government gold reserves fell from 600 million ounces in 1960 to about 300 million ounces in 1968.

A "two-tier" gold price system was consequently established in 1968 where the official U.S. gold price was restricted to monetary transactions involving government-owned gold, and an open market gold price, free to fluctuate with supply and demand, was recognized for other transactions. In 1970, the International Monetary Fund introduced "special drawing rights", an instrument which member countries could utilize in addition to U.S. dollars and gold to finance international trade, providing greater monetary liquidity. Finally, the flow of gold from the U.S. treasury to other governments was stemmed in 1971 by a presidential order ending the convertibility of U.S. dollars into gold. Since that time the free market has flourished, while gold's monetary

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5. A country is said to be on the "gold standard" when its central bank (the Federal Reserve System in the United States) is obliged to give gold in exchange on presentation of any of its currency.
6. These government policies included loans to cover losses and negative taxation for short-lived and marginal gold mines in South Africa, direct government grants and tax-exempt status for Australian gold mines, and the cost assistance provided under the Emergency Gold Mining Assistance Act in Canada.

role has evolved to the point where most countries conduct gold transactions and value their gold reserves at market-related prices.

1946-85 Trends

Average annual gold prices for the 1946-85 study period are presented in table 3. To be relevant for policy and planning in Canada, the gold price series is standardized in constant 1985 Canadian dollars, as shown in the right-hand column. The procedure followed in deriving this time series is summarized as follows.

i The annual price of gold is initially established in current U.S. dollars per ounce. This series averages the actual prices which occurred each year in the international gold market. Note that the gold price was fixed at $35 per ounce until 1967.

ii The average annual C$/U.S.$ exchange rate is used to convert each year's current U.S. dollar gold price to the equivalent Canadian dollars per ounce. In different years, current dollars (both United States and Canadian) have different purchasing powers. In other words, current dollar price series such as shown in the second and fourth columns of table 3 include the effects of inflation.

iii To examine real constant dollar trends, inflationary effects have to be removed from the current dollar price series. Constant dollar gold prices exclude the effects of inflation. Since the purchasing power of a dollar is assumed to remain constant, some year is specified to define the constant money base, e.g. 1985. Thus, as shown in table 3, the Gross National Expenditure (GNE) Implicit Price Index for Canada and the associated inflation multiplier series (1985 = 1.00) are applied to convert the current Canadian dollar gold prices to constant 1985 Canadian dollar equivalents.

The average annual gold price series in constant 1985 Canadian dollars derived in the right-hand column of table 3, is illustrated in figure 1. From 1946 to 1967, the price of gold generally declined as a result of the fixed $35-per-ounce nominal price and inflation. The minor price increases shown in 1950, 1954, and 1961-62 were caused by devaluations of the Canadian dollar. Although these fluctuations now appear minor,

Table 3

AVERAGE ANNUAL PRICE OF GOLD
(per ounce)

YEAR	CURRENT US$ PRICE	EXCHANGE RATE (C$/US$)	CURRENT C$ PRICE	GNE IMPLICIT PRICE INDEX	INFLATION MULTIPLIER (1985=1.00)	CONSTANT 1985 C$ PRICE
1946	35.00	1.0575	37.01	42.0	7.46	276.11
1947	35.00	1.0025	35.09	45.7	6.85	240.35
1948	35.00	1.0025	35.09	51.3	6.11	214.38
1949	35.00	1.0308	36.08	53.5	5.85	211.06
1950	35.00	1.0892	38.12	54.8	5.72	218.06
1951	35.00	1.0528	36.85	61.0	5.13	189.03
1952	35.00	0.9789	34.26	63.7	4.92	168.57
1953	35.00	0.9834	34.42	64.6	4.85	166.93
1954	35.00	0.9732	34.06	63.6	4.92	167.59
1955	35.00	0.9863	34.52	65.0	4.82	166.39
1956	35.00	0.9841	34.44	67.4	4.65	160.16
1957	35.00	0.9588	33.56	68.8	4.55	152.69
1958	35.00	0.9706	33.97	69.8	4.49	152.53
1959	35.00	0.9590	33.57	71.2	4.40	147.69
1960	35.00	0.9697	33.94	72.1	4.34	147.30
1961	35.00	1.0312	36.09	72.4	4.33	156.28
1962	35.00	1.0689	37.41	73.4	4.27	159.75
1963	35.00	1.0785	37.75	74.8	4.19	158.16
1964	35.00	1.0786	37.75	76.6	4.09	154.40
1965	35.00	1.0780	37.73	79.1	3.96	149.41
1966	35.00	1.0773	37.71	82.6	3.79	142.90
1967	35.00	1.0787	37.75	85.9	3.65	137.80
1968	39.85	1.0728	42.75	88.7	3.53	150.91
1969	41.06	1.0768	44.21	92.6	3.38	149.44
1970	35.97	1.0769	38.74	96.9	3.23	125.12
1971	40.80	1.0097	41.20	100.0	3.13	129.03
1972	58.13	0.9903	57.57	105.0	2.98	171.55
1973	97.22	1.0000	97.22	114.6	2.73	265.41
1974	159.26	0.9780	155.76	132.1	2.37	369.14
1975	161.02	1.0173	163.81	146.3	2.14	350.54
1976	124.84	0.9861	123.10	160.4	1.95	240.05
1977	147.72	1.0635	157.10	172.3	1.82	285.92
1978	193.23	1.1407	220.42	183.8	1.70	374.71
1979	306.69	1.1714	359.26	202.7	1.55	556.85
1980	612.56	1.1693	716.27	225.8	1.39	995.61
1981	459.72	1.1989	551.16	249.7	1.25	688.95
1982	375.39	1.2337	463.12	275.5	1.14	527.96
1983	424.18	1.2324	522.76	290.1	1.08	564.58
1984	360.44	1.2591	453.83	298.3	1.05	476.52
1985	317.00	1.3655	432.86	313.2	1.00	432.86

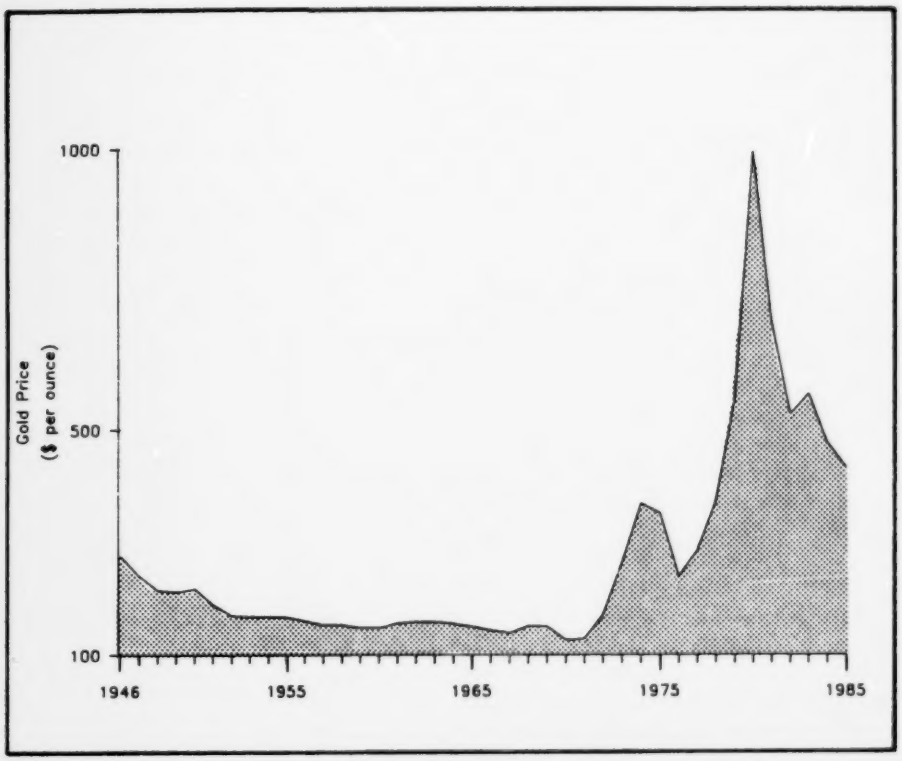

Figure 1. Average Annual Price of Gold

they were important to individual gold producers struggling to survive the cost-price squeeze. By 1967, the gold price was less than half that which had prevailed in 1946.

In 1968, the central banks of seven countries - the United States, the United Kingdom, Germany, Italy, Belgium, the Netherlands, and Switzerland - established the two-tier price system whereby the official price of gold involved in government transactions would remain fixed at U.S. $35 per ounce, but gold bought and sold on the open market could seek its own price level. This event set the stage for the dramatic price increases which occurred during the following decade. The transition of gold from its traditional monetary role to a form of investment was several years in the making. As shown in figure 1, except for setbacks in 1969-70 and 1975-76, the gold price gathered momentum, accelerating to the "spike" in 1980, representing an average annual price of $996 per

ounce.[7] From 1980 to 1985 the trend was basically downwards, the average gold price falling to $433 per ounce, less than half the 1980 price, by 1985.[8]

The reason for these historical gold price fluctuations and trends is not easy to unravel. The fundamental supply and demand factors which explain all mineral commodity markets are, in the case of gold, overlain by a complex set of economic, sociological, and political intangibles. The initial 1971-74 uptrend was stimulated by the commodity price boom, the first oil price shock, rising inflation rates, the weakening U.S. dollar, and uncertainties concerning interest rates. The excessive price rise in 1976-80 was encouraged by the international political situation, including the OPEC oil embargo and the crisis in Iran, negative real interest rates, the rising trend to double-digit inflation rates, and immoderate speculation in futures exchanges, including the notorious move of the Hunt brothers into silver.

The decline in gold prices during 1980-85 is mainly attributable to the sharp rise and sustained level of real interest rates, and to the unusual strength of the U.S. dollar. With the strong dollar established as the overriding influence, gold prices, expressed in domestic currencies, held up well, remaining broadly unchanged in some important markets such as Britain, Italy, and Switzerland, reaching record levels in South Africa, and only declining significantly in the United States, Japan, and Canada. The price no longer appeared to move in response to political events, and the relationship between the value of the U.S. dollar and the price of gold weakened.

The large price rises in the late 1970s were more pronounced in Canada as a result of the decreasing value of the Canadian dollar in U.S. dollar terms (see table 3). During the 1980-85 interval, the Canadian dollar continued to devalue, easing the impact of the fall of gold prices.

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7. The average annual gold prices shown in figure 1, mask the price fluctuations which occur on a weekly and daily basis. For example, the peak average annual price of $996 per ounce in 1980 incorporates a record spot price of $1182 per ounce attained on January 21, 1980.
8. The gold price, which averaged U.S. $366 per ounce in 1986, had risen to U.S. $480 per ounce in October 1987. In terms of constant 1985 Canadian dollars these prices are equivalent to $480 and $600 per ounce respectively.

3. GOVERNMENT INVOLVEMENT: THE EMERGENCY GOLD MINING ASSISTANCE ACT

For the first half of this century, gold was the most important mineral commodity produced in Canada. The discovery and mining of gold deposits and the establishment of mining communities opened up many regions which would otherwise have remained undeveloped. By the late 1940s, however, a critical situation had developed. The fixed nominal U.S. $35-per-ounce gold price and cost inflation were combining to endanger the survival of large numbers of gold mines with consequent implications for their employees and the associated communities.

To address this issue, the Emergency Gold Mining Assistance (EGMA) Act, which provided temporary financial assistance to Canadian gold mines, was given royal assent in May 1948. The purpose of this support which was based on production costs was to ease the rate of decline in gold mining and to thereby allow more time for the establishment of other economic activities in the dependent regions and communities.

EGMA, initially enacted for a three-year period, applied to mines producing at least 50 ounces of gold in a given year provided gold accounted for at least 70 percent of the total value of mine production. All gold produced under this assistance program had to be sold to the Canadian Mint with the exception of gold contained in concentrate refined in a foreign country.

Payments to lode gold mines were based on the formula:

EGMA Payment = (Rate of Assistance)(Eligible Ounces).

Table 4 outlines the method of calculating the rate of assistance and the eligible ounces in the original act as well as in the various amendments which were subsequently legislated. Costs covered by EGMA for determining the rate of assistance were defined as charges relating to mining, milling, smelting, refining, transportation, administration, and mine exploration and development, as well as an allowance for depreciation of capital expenditures. An example illustrating the calculation of EGMA payments for the original program and for each of the amendments is shown in appendix III.

A summary of the effects of this federal government assistance program is given in table 5. EGMA payments during the period 1948-71 totalled $1.3 billion in constant 1985 Canadian dollars (or, in other words, $298 million in current dollar terms). On average, 88 percent of the mines in production and 78 percent of the ounces of gold recovered

Table 4

TERMS OF THE EMERGENCY GOLD MINING ASSISTANCE ACT

From	Rate of Assistance	Eligible Ounces	Notes
January 1948	1/2 of amount by which costs exceed $18 per ounce to maximum rate of $16 per ounce.	All ounces eligible for first year of mine production. Otherwise, the greater of 1/3 annual production or production above 2/3 of "base year" production eligible.	"Base year" for producing mines: July 1946 - June 1947 Otherwise, "base year" is first full year of mine production.
January 1950	Maximum rate reduced to $12.50 per ounce.		Reduction in maximum rate due to favourable change in C$/U.S.$ exchange rate.
January 1951	1/2 of amount by which costs exceed $22 per ounce to maximum rate of $11.50 per ounce.	The greater of 1/2 annual production or 1/2 production in "base year" eligible.	Shift in assistance to higher cost producers.
January 1953	1/2 of amount by which costs exceed $18 per ounce to maximum rate of $13.50 per ounce.	Annual production in excess of 1/2 production in "base year" eligible.	Increased rate of assistance partly due to unfavourable change in C$/U.S.$ exchange rate.
January 1955	2/3 of amount by which costs exceed $26.50 per ounce to maximum rate of $12.33 per ounce.	2/3 of annual production eligible.	Shift in assistance to higher cost producers.
January 1958	Same method of calculation. 25 percent added to total payment.		
June 30 1965			New mines receive assistance only if located in established mining camps.
August 30 1971			Mines receive assistance only if in operation prior to August 1970.
June 30 1976			EGMA terminated.

Table 5

EGMA PAYMENTS TO LODE GOLD MINES

YEAR	LODE GOLD MINES			OUNCES PRODUCED			EGMA PAYMENTS		
	IN PRODUCTION (number)	EGMA ASSISTED (number)	EGMA ASSISTED (percent)	TOTAL (thousands)	ELIGIBLE FOR EGMA (thousands)	EGMA ASSISTED (percent)	TOTAL ($ million)	PER ELIGIBLE OUNCE ($)	PER TOTAL OUNCE ($)
1948	87	87	100	3093	3092	100	62	20	20
1949	92	92	100	3533	3522	100	71	20	20
1950	84	82	98	3766	3424	91	50	15	13
1951	79	75	95	3701	3173	86	53	17	14
1952	74	61	82	3856	2809	73	52	18	13
1953	69	64	93	3514	3103	88	69	22	20
1954	65	62	95	3723	3711	100	78	21	21
1955	61	50	82	3868	2924	76	41	14	11
1956	58	45	78	3701	2437	66	39	16	11
1957	53	44	83	3768	2658	71	44	16	12
1958	55	44	80	3884	2598	67	50	19	13
1959	54	44	81	3834	2376	62	52	22	13
1960	55	44	80	3903	2385	61	53	22	14
1961	53	41	77	3758	2325	62	54	23	14
1962	53	43	81	3473	2279	66	60	26	17
1963	51	42	82	3293	2545	77	59	23	18
1964	55	46	84	3148	2607	83	62	24	20
1965	56	47	84	2924	2395	82	60	25	21
1966	48	44	92	2659	2202	83	58	26	22
1967	44	40	91	2418	1892	78	55	29	23
1968	38	36	95	2177	1616	74	51	31	23
1969	34	33	97	2018	1458	72	45	31	23
1970	32	31	97	1848	1667	90	44	26	24
1971	30	28	93	1720	1303	76	36	28	21
TOTAL			88 avg.	77580	60502	78 avg.	1300	22 avg.	18 avg.

received assistance. The assistance paid was equivalent to about $22 per eligible ounce and $18 per total ounce produced.

To a certain extent, the proportion of mines and ounces subsidized by EGMA (table 5) reflects the changing structure of EGMA (table 4). Initially, a very high percentage of mines and ounces received assistance. The 1951 and 1955 amendments in particular represented major shifts in emphasis towards higher cost producers. The associated decreases in the proportion of mines and ounces receiving EGMA payments are shown in table 5. Increasing coverage during the 1961-71 period is attributable to the cost-price squeeze, which was by then affecting even the lower-cost producers, rather than to any change in the structure of EGMA.

While EGMA payments per ounce doubled from 1955 to 1971, the total amount of assistance is shown in table 5 to be fairly evenly distributed over the 1948-71 period. Because of the increase in the free

market price of gold in the early 1970s (table 3 and figure 1), no payments were made after 1971. The Act was terminated in 1976. Nevertheless, a lobby formed for continuation of the program to provide a minimum gold price level of support.9

Although EGMA cost Canadian taxpayers $1.3 billion, it can be credited with helping preserve a mainly Canadian-owned industry and the associated mining communities. To place the total amount of assistance in perspective, the value of lode gold production in Canada has averaged almost $1 billion per year since 1980.

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9. In 1976, the open market gold price dropped from a high of $140 per ounce in January to below $110 per ounce in July. The gold mine operators, through The Mining Association of Canada, approached the federal government seeking assistance to once again keep the marginal gold mines operating.

4. GOLD MINE PRODUCTION

Several facets of Canadian gold mine production are examined in this chapter. First, the trend in the number of mines in production is outlined. The makeup of gold production from these mines is then considered in terms of:

- size and grade of ore reserves,
- rate of ore production,
- grade of ore mined,
- amount of gold recovered.

Number of Producing Mines

Table 6 shows the number of mines in production at the beginning and end of each year during the period 1946-85 as well as the number of mine openings and closures each year. For example, in 1946 there were 69 producers at the beginning of the year. During the year two new mines opened and seven former producers reopened while one mine closed. Thus at year end there were 77 mines in production (69 + 2 + 7 - 1 = 77).

The right-hand column in table 6 shows the maximum number of mines recording production each year, a figure that represents the number of producers at the beginning of the year plus the number of mine openings and reopenings during the year. For example, there were 69 mines producing at the beginning of 1946, and a total of nine new and former producers opened during the year, giving a total of 78 mines which produced during the year.

Of the 169 mines recording production over the 1946-85 period, 69 were producing at the beginning of 1946, while 78 new mines were opened and 22 pre-1946 producers were reopened. An alphabetical listing of these 169 mines, which form the basis for the study data base, is provided in appendix IV. They are classified into three dynamic groups: gold mines which had produced prior to 1946; gold deposits discovered prior to 1946 and brought into production during the 1946-85 period; and gold deposits discovered and brought into production during the study period.

The maximum number of mines producing each year (right-hand column of table 6) is used in this study for the determination of annual statistics. During the 40-year study period, the maximum number of mines is shown to have increased from 78 in 1946 to a peak of 91 in

Table 6

NUMBER OF PRODUCING GOLD MINES

YEAR	NUMBER PRODUCING AT BEGINNING OF YEAR	OPENINGS		CLOSURES	NUMBER PRODUCING AT END OF YEAR	MAXIMUM NUMBER PRODUCING DURING YEAR
		NEW MINES	FORMER PRODUCERS			
1946	69	2	7	1	77	78
1947	77	4	5	7	79	86
1948	79	9	3	5	86	91
1949	86	3	2	10	81	91
1950	81	3	1	5	80	85
1951	80	3	0	9	74	83
1952	74	0	0	7	67	74
1953	67	0	1	6	62	68
1954	62	0	1	4	59	63
1955	59	1	0	3	57	60
1956	57	1	0	7	51	58
1957	51	0	1	0	52	52
1958	52	0	1	3	50	53
1959	50	1	1	2	50	52
1960	50	2	1	2	51	53
1961	51	1	0	4	48	52
1962	48	2	0	2	48	50
1963	48	0	0	3	45	48
1964	45	4	1	3	47	50
1965	47	4	1	8	44	52
1966	44	2	2	9	39	48
1967	39	3	0	5	37	42
1968	37	0	1	4	34	38
1969	34	1	0	5	30	35
1970	30	1	0	3	28	31
1971	28	0	0	8	20	28
1972	20	0	0	1	19	20
1973	19	1	0	0	20	20
1974	20	1	0	1	20	21
1975	20	0	0	2	18	20
1976	18	0	0	1	17	18
1977	17	0	0	1	16	17
1978	16	0	1	0	17	17
1979	17	4	1	0	22	22
1980	22	1	2	0	25	25
1981	25	5	2	3	29	32
1982	29	6	2	1	36	37
1983	36	4	3	2	41	43
1984	41	4	0	7	38	45
1985	38	5	0	5	38	43

1948-49, before declining to a low of 17 producers in 1977-78. Since that time, the number of gold mining operations has increased markedly, reaching 43 mines in 1985.

Size and Grade of Ore Reserves

The size and grade of lode gold ore reserves have been calculated on a mine-by-mine basis at the end of each year for the period 1946-85.[10] Aggregate results for the Canadian lode gold mining sector are shown in relation to the constant dollar gold price in figure 2.

The size of ore reserves varied from a low of 17 million tonnes in 1971 to a peak of 160 million tonnes in 1985. Ore reserves increased from 60 million tonnes in 1946 to 72 million tonnes in 1950 as new mines came on stream after World War II. Thereafter, the size of ore reserves showed a decreasing trend until 1971 when the period low of 17 million tonnes was recorded. This trend resulted from a combination of several factors, the most obvious of which was the decreasing number of producers. The size of ore reserves in the remaining mines also decreased. These trends were partly the result of increasing cut-off

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10. The calculation, recording, and reporting of ore reserves varies among mines and, as a result, it is often difficult to judge whether recorded figures represent geologic or recoverable reserves, or, in other words, to determine whether mine recovery and dilution factors have been applied.

    In an attempt to overcome the inconsistencies in ore reserve data, the following procedure has been adopted for recording ore reserves in the study data base. Most mines possess a good knowledge of what portion of the available ore is being removed and thus it is assumed that mine recovery factors have been applied when reporting ore reserves. Establishing a dilution factor is a more difficult procedure and is likely to be less reliable than the mine recovery factor. Gold mine dilution factors reported in company annual reports are without exception in the range of 10-20 percent. Based on these estimates, 15 percent has been chosen as a representative dilution factor and applied to reserves in cases where there is no reported dilution factor.

    Another problem area when examining ore reserves is the extent to which recorded reserves at the end of any given year reflect the total remaining reserves in the mine. The year-end reserves which are reported are usually more of a working inventory than a complete assessment of total remaining reserves. Maintaining this working inventory rather than outlining total reserves is the economic purpose of ongoing delineation at most mines. Historically, most gold mines maintain an ore reserve inventory of three-to-five-years production. During the 40-year study period, the number of years of production represented by year-end reserves varies from a low of three years during most of the interval 1961-72, to a high of 14 years in 1985.

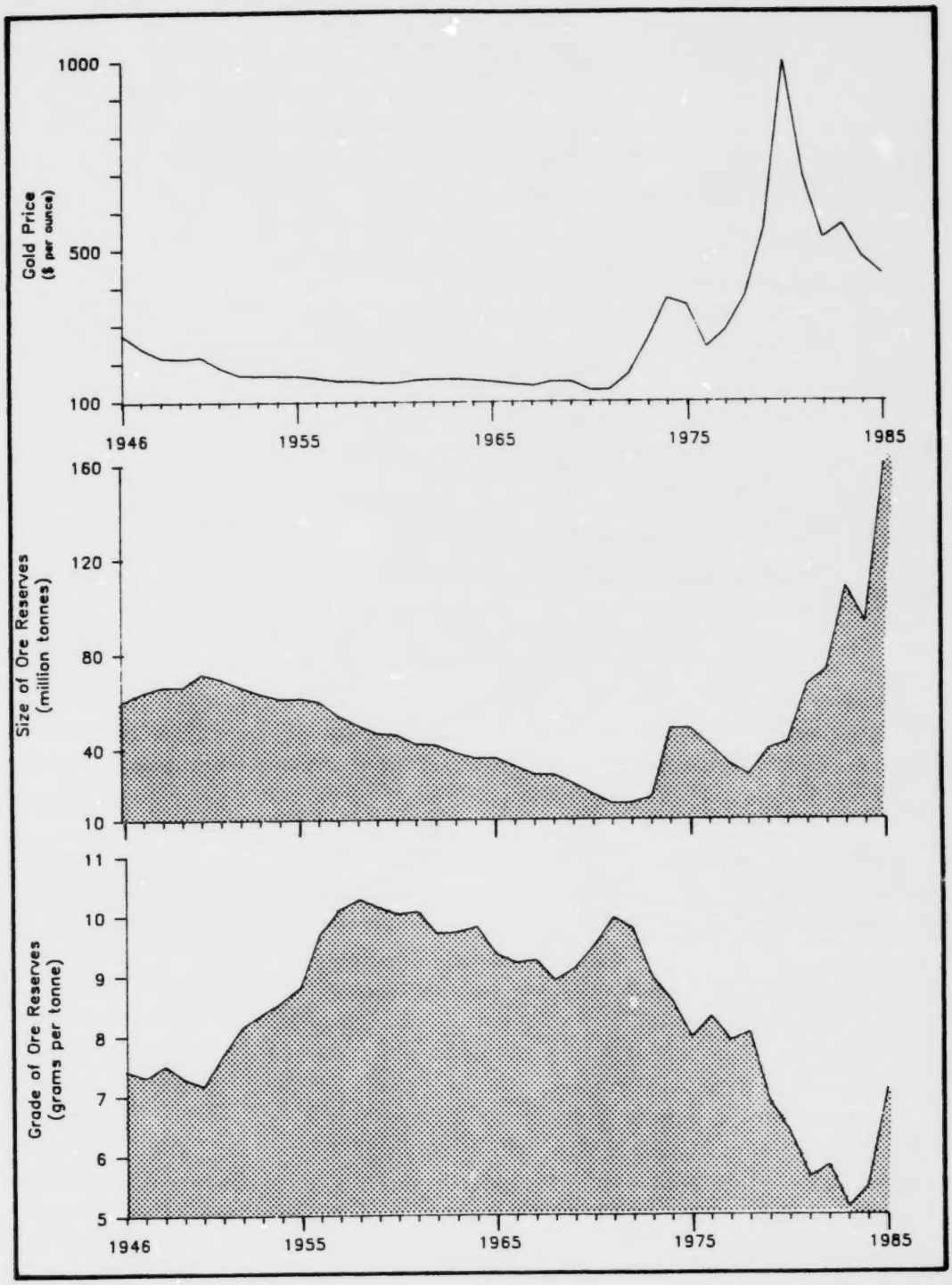

Figure 2. Size and Grade of Ore Reserves

grades which rendered fewer tonnes of ore available. Also, as mine operators endeavoured to reduce costs to counteract the decreasing constant dollar price of gold, the development of new ore reserves was curtailed and mines operated increasingly on a "hand-to-mouth" basis.

From 1971 to 1985, the trend in size of ore reserves was generally similar to the trend in gold price, lagging by one or two years. For example, as shown in figure 2, gold price increases during the 1971-74 interval resulted in an increase in the size of ore reserves. This occurred even though the number of producing mines declined from 28 to 21, which suggests that the ore reserves of the remaining producers increased substantially through a lowering of cut-off grades. The continued decrease in the number of producers, from 20 in 1975 to 17 in 1978, combined with lower gold prices during 1974-76, resulting in a decline of ore reserves from 49 million tonnes in 1974 to 28 million tonnes in 1978. From 1978 to 1983, both the gold price and the number of producers increased markedly, resulting in an increase in the size of ore reserves from 28 million tonnes to 108 million tonnes. While a decrease in both gold price and size of ore reserves occurred in 1984, the inclusion for the first time of ore reserves from the three Hemlo mines in 1985 caused a large jump in ore reserves to an all-time high of 160 million tonnes.

The weighted average grade of ore reserves is shown in the bottom panel of figure 2 to vary from a high of 10.2 grams per tonne (g/t) in 1958 to a low of 5.1 g/t in 1983. Between 1946 and 1950, the average grade of reserves decreased slightly from 7.4 to 7.2 g/t. The average grade then increased each year until 1958, reflecting the higher cut-off grades needed to offset increasing costs and the decreasing gold price. New mines coming on stream at this time were generally of a relatively high grade, which also acted to increase the overall average. The average grade was further increased as lower-grade mines were forced to close. From 1959 to 1968, the grade of ore reserves showed a decreasing trend. This is attributable to somewhat stronger gold prices arising from the weak Canadian dollar. During the 1969-71 interval, the average grade of ore reserves increased, reflecting the record low gold price prevailing at that time. The trend from 1972 to 1985 was generally downward as the gold price increased and as new lower-grade mines came on stream. The sudden increase in grade for 1985 is caused by the inclusion of the Hemlo mine ore reserves. Generally, with a time lag of one or two years, the grade of ore reserves is shown in figure 2 to be an inverse function of the gold price.

Rate of Ore Production

A total of approximately 398 million tonnes of ore were mined during the 1946-85 period. The larger producers played a relatively important role. For example, of the 169 mines which produced during the period, the 25 largest producers (15 percent of the total) each mined at least 3.5 million tonnes of ore and together accounted for 70 percent of the total tonnage produced.

The trend in tonnes of gold ore mined per year in relation to the constant dollar price of gold is illustrated in the first and second panels of figure 3. The rate of ore production is shown to vary from a high of about 15 million tonnes in 1950 to a low of 5 million tonnes in 1974.

During the 1946-60 interval, total ore production increased from 10 million tonnes to 13 million tonnes per year (t/y). At the same time, the number of producing mines (table 6) decreased from 78 to 53. This indicates that the rate of ore production for the remaining mines had greatly increased. The trend towards increased ore production rates during this interval is illustrated in the second panel of figure 4. For example, in 1946, one-half of the total tonnage came from mines with a rate of production of more than 200,000 t/y, while in 1960, one-half the tonnage was being produced by mines with annual rates of production greater than 410,000 t/y. As well, the lower and upper quartile production rate statistics increased during this interval from 104,000 to 179,000 t/y and from 388,000 to 686,000 t/y respectively.

From 1961 to 1974 there was a further substantial reduction in the number of producing mines, as shown in table 6, from 52 to 21. In contrast with the 1946-60 interval, however, the remaining producers were unable to increase ore production to offset the tonnage lost through mine closures. As a result, the total tonnes of ore mined decreased from 13 million tonnes in 1961 to 5 million tonnes in 1974. The overall 1946-74 trend suggests that the cost-price squeeze affecting the gold mining sector acted to initially force the closure of small marginal producers and, then, with time, to cause a decrease in the rate of mine production and/or closure of the larger, more stable producers.

From 1975 to 1985, the overall rate of ore production increased from 5 million tonnes to 12 million tonnes. During 1975-81, the number of producing mines increased by 60 percent from 20 to 32. Over this same interval the overall rate of ore production increased by only 18 percent. This indicates that most of the new mines came into production at relatively low rates. Larger deposits requiring more time to develop started to come on stream during the 1981-85 interval. In addition,

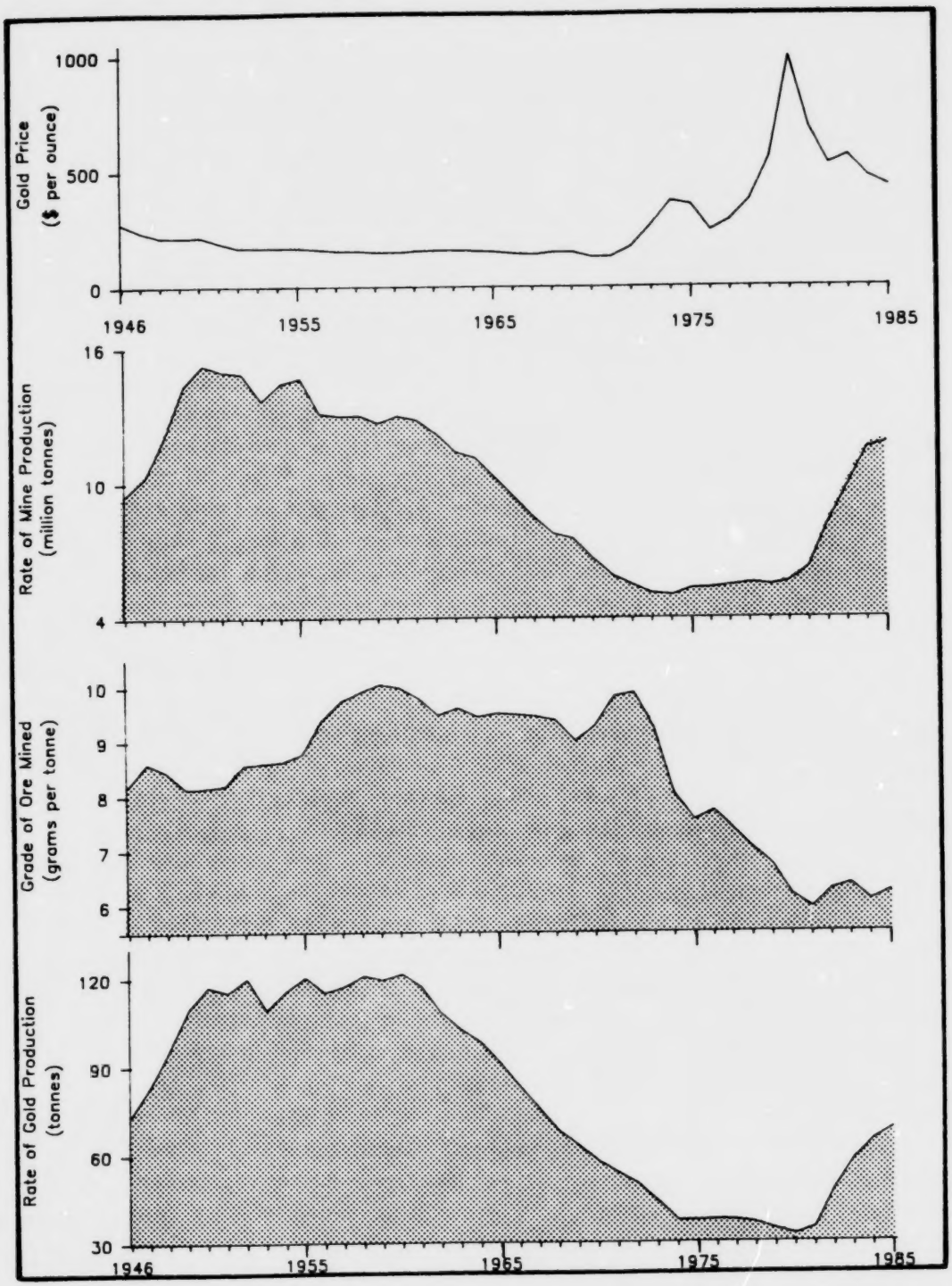

Figure 3. Gold Mine Production

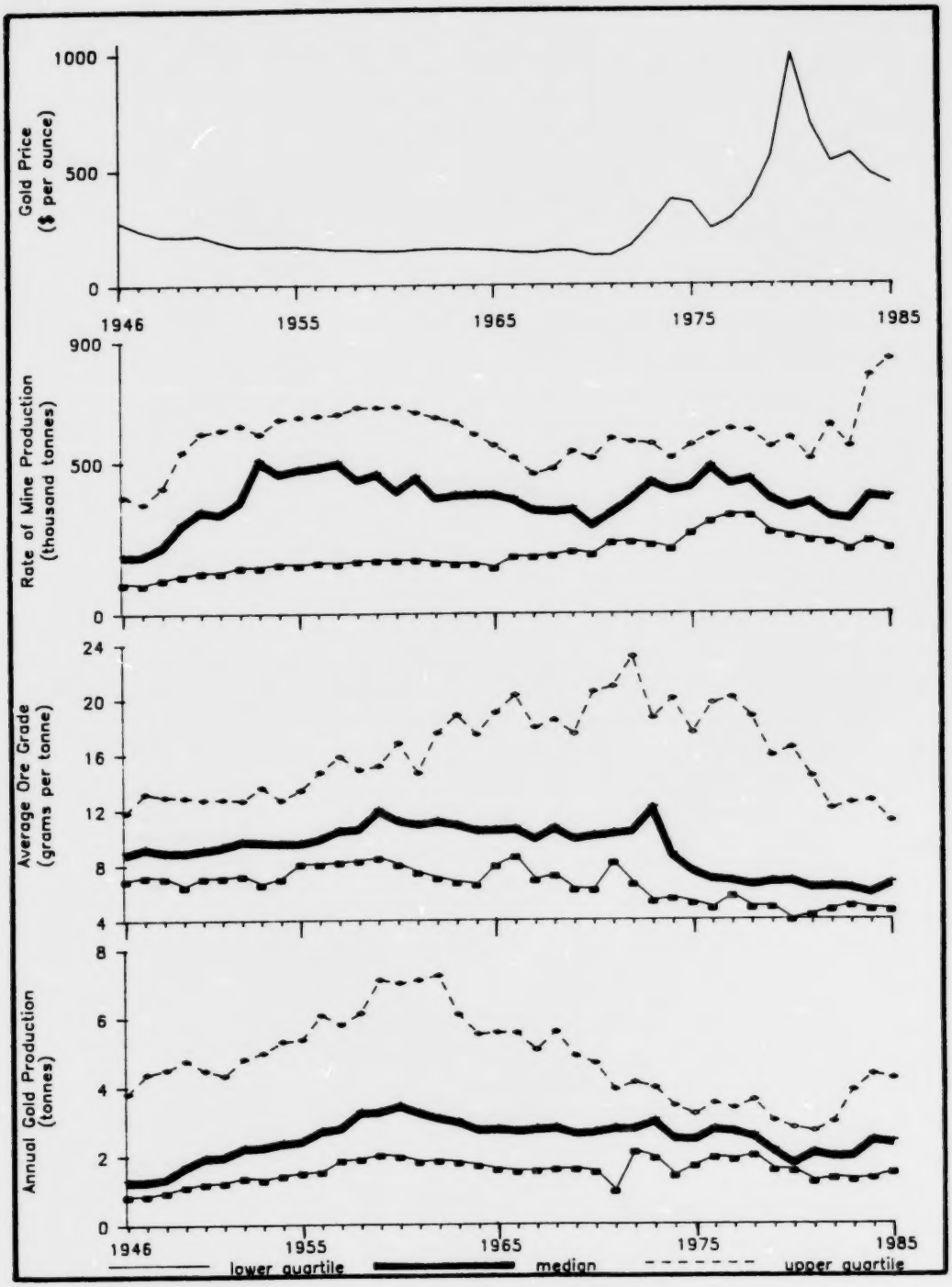

Figure 4. Key Statistics: Gold Mine Production

expansions were underway for many of the existing producers (as had happened in 1946-60), and as a result both the average rate of ore production and the total tonnes produced showed major increases. The 12 million tonnes mined in 1985 represented the highest rate of gold mine production in Canada since 1962.

Grade of Ore Mined

Figure 3 (third panel) shows the annual weighted average grade of lode gold ore mined in Canada during the period 1946-85. Ore grades are shown to vary from a high of 10.0 g/t (0.29 ounces per ton) in 1959, to a low of 5.9 g/t (0.17 ounces per ton) in 1981.

An inverse relationship between ore grade and the price of gold is evident in figure 3. For example, from 1946 to 1960, the constant dollar gold price declined every year except 1954, and the average grade of gold ore mined showed a generally increasing trend (with the exception of decreases in 1948-49 and in 1960), rising from 8.2 g/t in 1946 to 10.0 g/t in 1960. The increasing average grade of ore mined is a reflection of both the increase in cut-off grades resulting from decreasing gold prices and the closure of low grade, uneconomic mines.

Further evidence that the higher-grade deposits became increasingly important as a source of supply relative to the lower-grade deposits is contained in the third panel of figure 4. The median grade statistic for 1946 shows that one half of the gold produced came from operations mining at an average grade of less than 9.0 g/t. By 1960, this value had increased to 11.3 g/t. Similarly, the upper quartile statistic indicates that, in 1946, one quarter of the gold produced came from mines with an average grade of more than 11.9 g/t while by 1960, one quarter of the gold was supplied from mines producing at average grades greater than 16.9 g/t.

In 1961 and 1962, the price of gold rose in Canada as its dollar declined in value relative to the U.S. dollar (table 3). This enabled a slight decrease in average grades mined, to 9.5 g/t in 1962. During the years 1963-67, the exchange rate remained favourable for Canadian gold miners and the average grade remained steady. Generally, for the entire 1946-68 period, the average grade mined was sensitive to changes in the exchange rate (or, in other words, to the Canadian dollar gold price).

When in 1968, the two-tier gold pricing system went into effect, the stage was set for the dramatic price increases of the late 1970s. The gold price declined in 1969 and 1970, and the average grade mined increased during 1970-72. From 1972, the gold price increased each year (except 1976) to peak at $996 per ounce in 1980. Consequently, the mean grade decreased each year (except 1976) to reach an all-time low of 5.9 g/t in 1981. Average ore grades increased slightly in 1982 and 1983, reflecting the drop in gold price in 1981 and 1982, before declining slightly to finish the period at 6.2 g/t in 1985.

Relationship Between Ore Reserve Grade and Grade of Ore Mined

It is interesting to examine the relationship between the average grade of ore mined and the average grade of ore reserves. As shown in figure 5, there is a good overall correlation between the weighted average grade of ore mined and the weighted average grade of ore reserves across the entire Canadian gold mining industry from 1946 to 1985. This correlation is not surprising considering the sensitivity of both these parameters to the gold price.

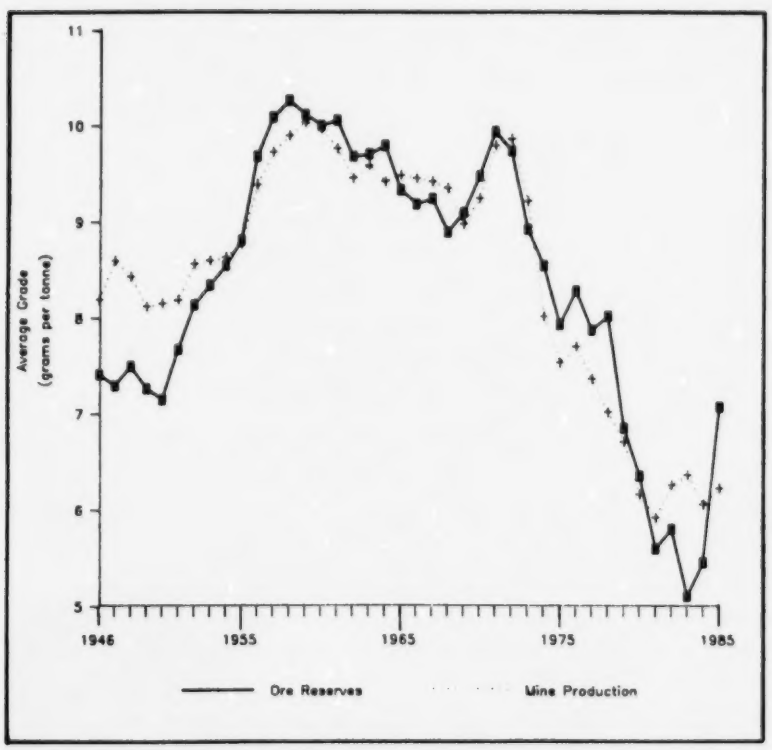

Figure 5. Relationship Between Average Grade of Ore Reserves and Average Grade of Ore Mined

For the period 1946-53, the average grade of ore mined was higher than the average grade of ore reserves. At this time many mines were reopening after World War II and there was probably a tendency to select higher than average grades for mining in the initial years of production to help pay back the capital investment of reopening and expansion. For the 20 year period 1953-73, Canadian lode gold mines as a group mined at approximately the average grade of ore reserves. This policy no doubt reflects the depressed state of the gold mining industry at the time. With the "hand-to-mouth" approach to mining caused by curtailment of mine exploration and development, the scope for varying the grade mined was limited. As a result, the grade of ore mined closely matched the grade of ore reserves at most mines.

During the 1974-79 period, the average grade mined was below the average grade of ore reserves - a result of rising gold prices. Since the development of new ore reserves made possible by the gold price increases did not keep pace with the decrease in grade mined, the average grade of reserves remained at a higher level than the average grade of ore mined.

The 1981-84 period saw the average grade of reserves once again fall below the grade mined. It is suggested here that this resulted from a catching up in the development of ore reserves and, probably, a certain amount of selective mining of higher-grade ore zones by the large number of new producers to speed up the recovery of development capital costs. In 1985, the average grade of ore reserves once again surpassed the grade of ore mined due to the inclusion, for the first time, of the relatively high grade ore reserves of the three Hemlo mines.

In South Africa, under the terms of mining lease agreements negotiated with the government, each gold mine is required to mine to the average grade of its ore reserves. While this type of government policy does not exist in Canada, it is interesting to note that a close correspondence is nevertheless shown to exist between average ore reserve and production grades during the 1946-85 study period.

Rate of Gold Production

The rate of gold production is the resultant of the two supply parameters already examined - rate of ore production and grade of ore mined - together with the mill recovery factor.

The mill recovery factor provides the link between the gold content in the ore mined and the amount of gold recovered in salable product (usually an impure bullion):

Gold Content in Ore Mined = (Ore Production) (Ore Grade);

Gold Produced = (Gold Content in Ore Mined) (Mill Recovery Factor).

Gold ores can be divided into two major groups: free milling ores and refractory ores. Free milling ores contain gold readily extracted by the cyanide leaching process. This method of extraction, developed in the 1890s, generally enables mill recovery factors in the range of 90 to 97 percent to be realized.

Refractory gold ores contain sulphide mineralization which impedes the extraction of the gold by cyanide leaching resulting in lower recovery rates. There have been notable improvements in the recovery of gold from refractory ores during the 1946-85 period. For example, at the Giant Yellowknife mine, the mill recovery factor increased to 85-89 percent towards the end of the study period, having been as low as 69 percent in the 1950s.

For the Canadian lode gold mining sector in general, the average mill recovery factor is shown by the study data base to have remained within the 92-94 percent range during the 1946-85 period. This average value reflects the processing of a high proportion of free milling gold ores.

During the 1946-85 period, Canadian lode gold production from 169 mines totalled 3,210 tonnes (or, about 103 million ounces). The rate of gold production is shown in the bottom panel of figure 3. At least one million ounces (about 32 tonnes) of gold have been produced in each of the 40 years of the study. The highest annual production, 121 tonnes (3.90 million ounces), was realized in 1960, and the lowest annual output, 32 tonnes (1.03 million ounces), was recovered in 1980.

Once again, the big mines predominated. The 24 largest operations (14 percent of the total number) each produced more than one million ounces (32 tonnes) during the 1946-85 study timeframe. Together, these mines accounted for 2,270 tonnes (73 million ounces) of Canada's lode gold output, or, in other words, 71 percent of the total.

From 1946 to 1960, annual gold production increased from 74 tonnes to 121 tonnes, while the number of producing mines declined from 78 to 53. This indicates that the average rate of gold production per mine increased markedly during this time - an increase verified by the median statistic in the bottom panel of figure 4. In 1946, one half of Canadian

lode gold production came from mines with an annual rate of production of at least 1.3 tonnes, whereas by 1960 the median value had increased to 3.5 tonnes.

During the 1961-74 interval, the annual rate of gold production in Canada declined from 117 tonnes to 37 tonnes as shown in figure 3. This decrease was accompanied by a further reduction in the number of producers, from 52 mines in 1961 to 21 mines in 1974. Unlike the 1946-60 interval, the remaining mines were unable to increase production to offset the lost gold production of the mines that closed. In fact, the average rate of gold production per mine also decreased. Figure 4 shows that in 1961 one half of the gold recovered came from mines producing at least 3.3 tonnes per year, whereas by 1974 the median rate had declined to 2.5 tonnes.

Gold production increased in 1975 and 1976, for the first time since 1960, but then declined over the next four years to reach in 1980 the study period's lowest annual rate of production - 32 tonnes. From 1980 to 1985, gold production more than doubled to 69 tonnes per year as the number of mines increased from 25 to 43. During this interval there was also a shift towards higher rates of production as new larger mines came on stream. In 1981, for example, as shown in the bottom panel of figure 4, one half of Canada's gold output was derived from mines producing at least 2.1 tonnes per year while by 1985, one half the gold came from mines producing at least 2.4 tonnes annually.

5. EMPLOYMENT IN GOLD MINING

Figure 6 presents employment statistics for lode gold mining in Canada during the 1946-85 period. With the exception of minor increases in the 1973-75 period, the number of gold mine employees decreased each year from a high of 22,906 in 1947 to a low of 4,645 in 1977, an 80-percent reduction in the work force over the 30-year period. The decline in importance of gold mine employment relative to other metal mines is shown in the third panel of figure 6. For example, in 1946, 62 percent of all metal mine employees worked in gold mines, whereas by 1977, the gold mining sector employed only seven percent of the total metal mine work force. The bottom panel in figure 6 provides a rough indicator of labour productivity measured by tonnes of ore mined per employee per year. Labour productivity increased from 433 tonnes of ore per employee in 1946 to 1,173 tonnes per employee in 1977, a 170-percent rise. The most pronounced increase in labour productivity occurred during the 1946-54 period, a time when, as previously noted, many small operations closed and the average rate of production per mine increased substantially. The associated economies of scale, including the introduction of larger and better equipment, acted to reduce the labour-intensive nature of gold mining,[11] helping realize the productivity gains shown in figure 6.

Since 1977, gold mine employment has shown a steady increase. The number of employees and the share of the total metal mine work force both reached 15-year highs in 1984. There was a slight decrease in employment in 1985 due to a reduction from 45 to 43 in the number of producing mines.

Although the tonnes of gold ore mined in 1985 was slightly higher than the rate of ore production achieved in 1963, the number of employees required fell from 14,408 to 7,862. Work force productivity had increased by 89 percent from 789 tonnes of ore per employee in 1963 to 1,496 tonnes per employee in 1985. It is interesting to note that the lowest labour productivity levels since the introduction of the two-tier gold pricing system occurred during 1973-74 and 1980-81, periods of peak gold prices. This supports the contention that pressures for productivity improvement tend to ease when market prices and profits are buoyant.

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11. The labour-intensive nature of gold mining may be illustrated by comparing labour productivity in lode gold mines and in nickel-copper mines. In 1950, labour productivity in gold mining was 678 tonnes of ore per employee per year as compared to 1,285 tonnes of ore in nickel-copper mining. By 1975, labour productivity in Canadian gold mines had improved to 918 tonnes per employee, as compared to 1,257 tonnes per employee in nickel-copper mines. No comparative data are available for the 1980s, a period of substantial improvement in the labour productivity of nickel-copper mines.

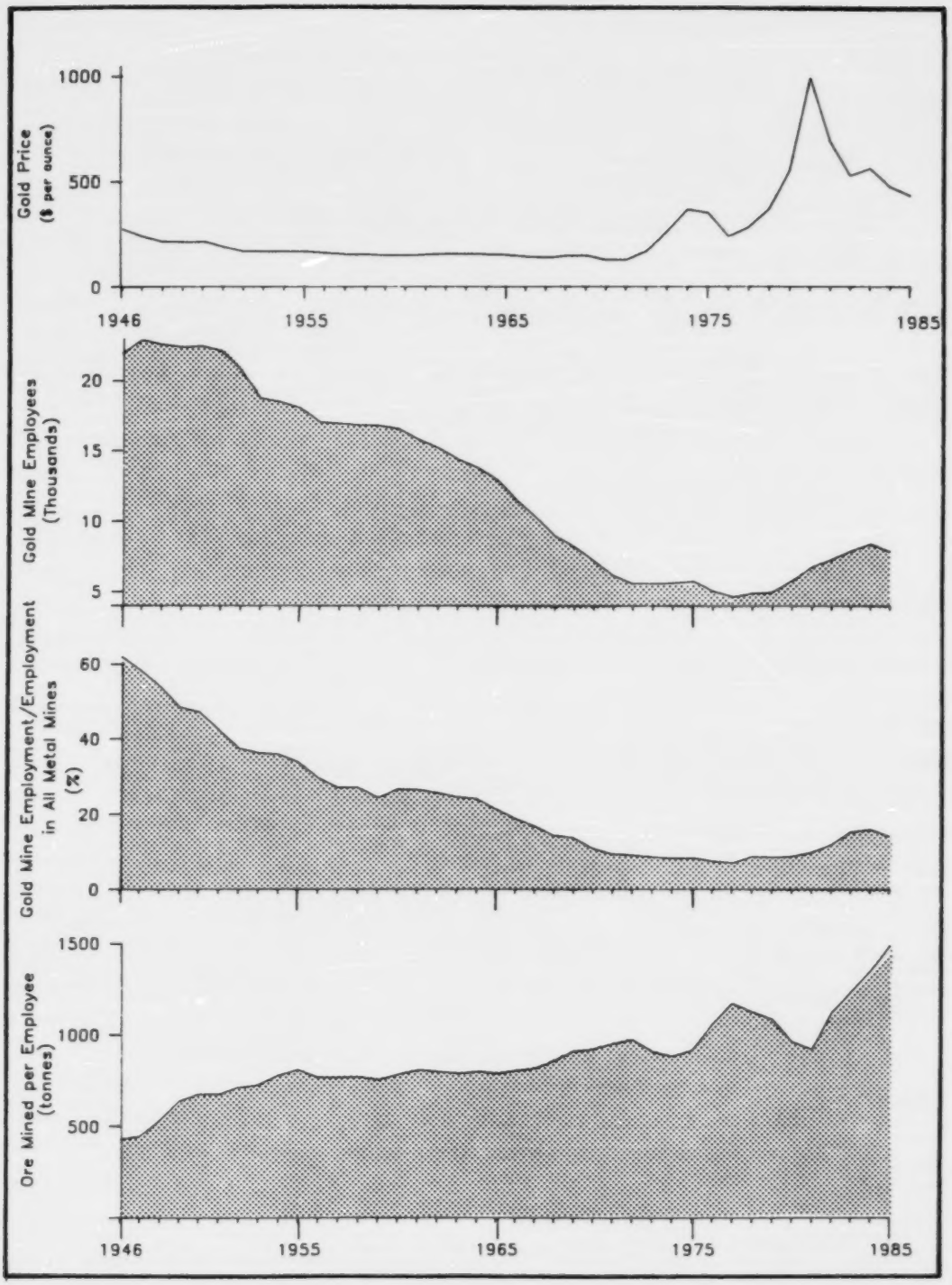

Figure 6. Employment in Gold Mining

6. MINE OPERATING COSTS

Aggregate Costs

Operating costs for lode gold mining in Canada during the 40-year study period total $17.3 billion. This compares with $22.8 billion of revenue realized from lode gold production (table 2). Figure 7 (middle panel) shows the trend in aggregate operating costs for lode gold mines during the 1946-85 period. Total operating costs peaked in 1950 at $663 million and then showed a decreasing trend, reaching an all-time low of $207 million in 1972. During the 1973-85 interval, total annual operating costs have increased rapidly, reaching $615 million in 1985.

Operating costs may be subdivided into three components:

- wages and salaries,
- fuel and electricity,
- materials and supplies.

The relative importance of these cost components in the makeup of total operating costs for the 1946-85 study period are as follows: wage and salary payments, 56 percent; materials and supplies, 37 percent; and fuel and electricity, 7 percent.

As shown in the bottom panel of figure 7, from 1946 to 1973 there was little change in these proportions, with wages and salaries accounting for 55-60 percent of the total, materials and supplies for 33-37 percent, and fuel and electricity for the remaining 6-7 percent. The relative importance of these components changed somewhat during the 1974-85 interval. By 1985, wage and salary costs had declined to 46 percent of total operating costs, materials and supplies had increased to 44 percent of the total, with fuel and electricity accounting for the remaining 10 percent.

Mine-Specific Unit Costs

Weighted average mine operating costs for each year from 1946 to 1985, expressed per tonne of ore mined and per ounce of gold recovered, are shown in figure 8. The weighted average operating cost per tonne of ore mined varied from $35 in 1953 to $69 in 1981, while the weighted average operating cost per ounce of gold recovered varied from $124 in 1958 to $388 in 1981. Time trends in these unit costs are examined within three time intervals as follows.

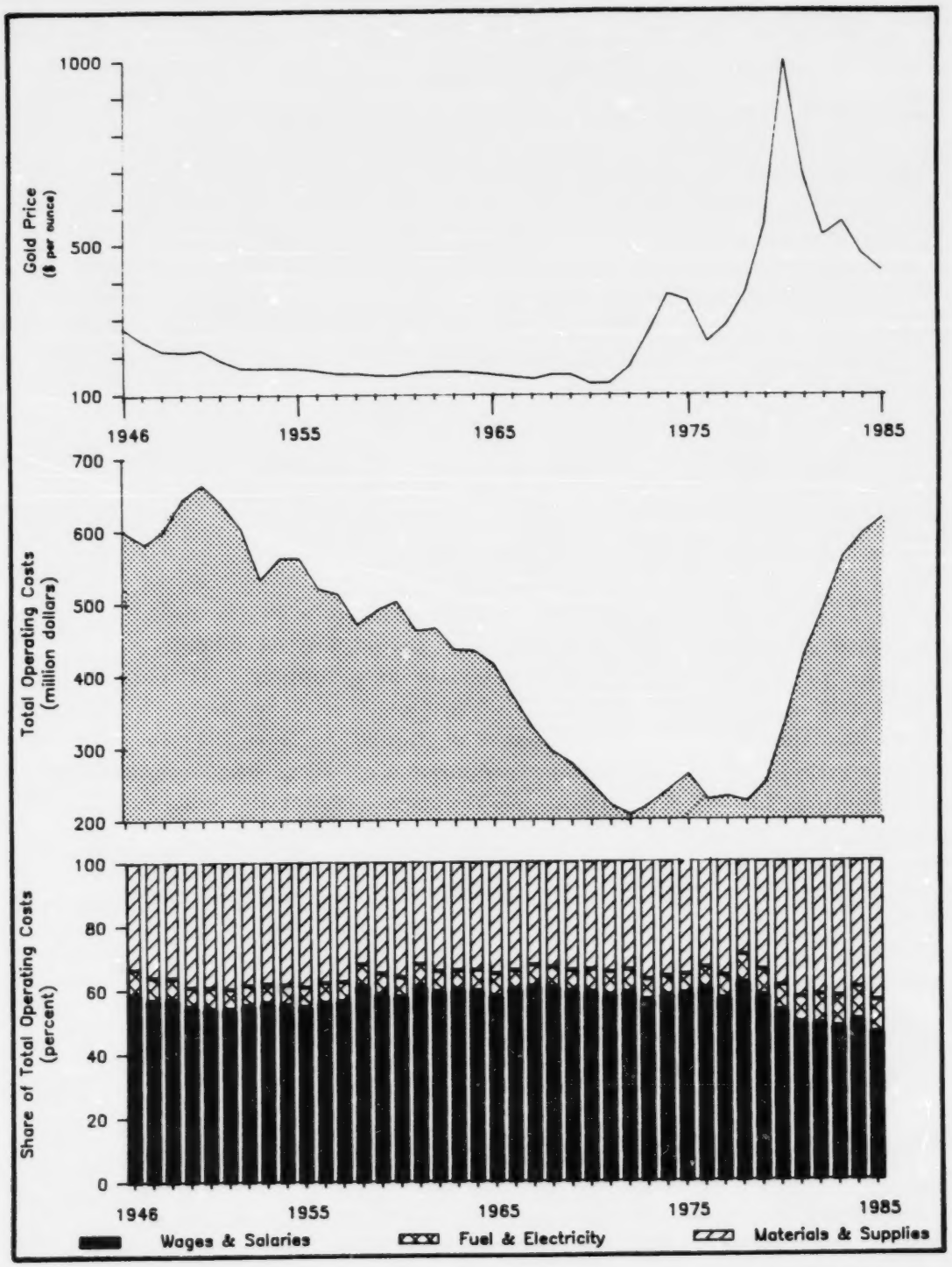

Figure 7. Aggregate Gold Mine Operating Costs

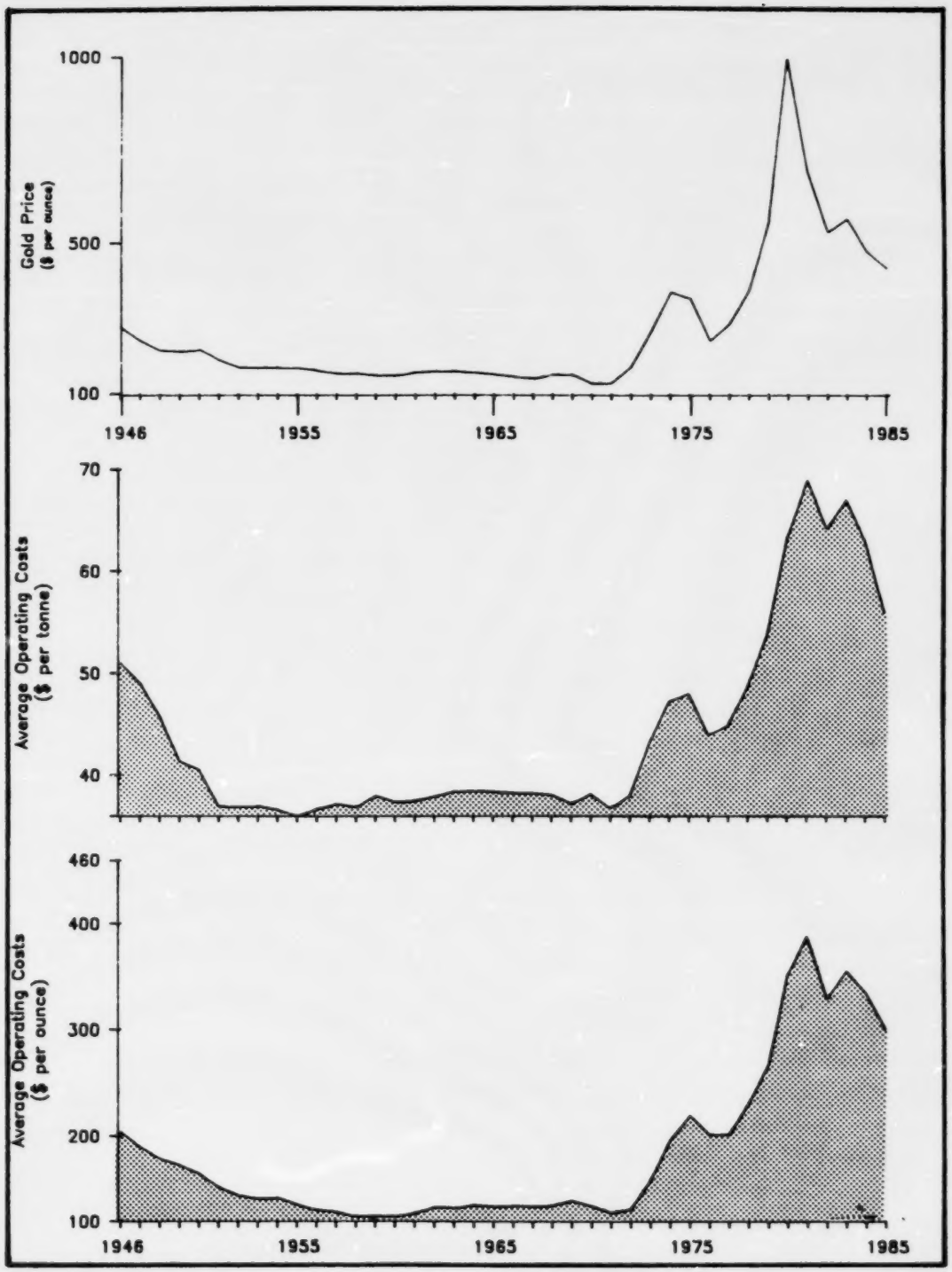

Figure 8. Unit Gold Mine Operating Costs

1946-60 Interval

The weighted average operating cost per tonne decreased from 1946 to 1950 as gold mining adjusted to postwar conditions. From 1951 to 1960, operating costs per tonne were controlled within the $35-37 range. This was made possible by the shift toward larger-scale producers. As average mine size increased, economies of scale allowed for more efficient production.

The weighted average operating cost per ounce of gold recovered, exhibited a decreasing trend over the 1946-60 interval falling from $204 in 1946 to $124 in 1960. This decrease, without a corresponding decline in cost per tonne, is explained by the increasing average grades mined. As previously shown, the average grade of ore mined rose during this period, causing the cost per ounce to decrease according to the relationship:

$$\text{Cost per Ounce of Gold Recovered} = \frac{\text{Cost per Tonne of Gold Ore Mined}}{(\text{Average Grade of Ore Mined})\ (\text{Mill Recovery Factor})}$$

This relationship implies that the cost per ounce should follow the gold price trend because, as previously shown in figure 3, the average grade of ore mined is an inverse function of the price of gold.

1961-72 Interval

For the period 1961-72, the weighted average operating cost per tonne was maintained within the $37-38 range. Unlike the 1946-60 interval when the total number of tonnes mined was maintained, costs per tonne were stabilized during the 1961-72 period by the forced closure of high-cost producers and the curtailment of ongoing exploration and development at operating mines. The weighted average operating cost per ounce during this period was also fairly stable, in the $125-140 range, showing some fluctuation after 1968 as the gold price began to respond to free market forces.

1973-85 Interval

During the 1973 to 1985 period, operating costs, which had been suppressed since the start of the study period, were given the opportunity to increase as the gold price rose, new mines opened, and the amount of ore mined increased. As shown in figure 8, both the cost per tonne and the cost per ounce followed the gold price trend, showing increases from 1972 to 1975, a decrease in 1976, and then increases until 1981, before declining somewhat to 1985. The weighted average operating cost per tonne of ore mined increased to $48 in 1975, declined to $44 in 1976, before climbing to an all-time high of $69 in 1981, and then decreasing to $56 in 1985. The weighted average operating cost per ounce of gold recovered, increasing from $159 in 1973 to $220 in 1975, dropping to $201 in 1976, peaking at $388 in 1981, and then declining to $301 in 1985.

7. DYNAMIC COMPONENTS OF GOLD SUPPLY

This chapter analyzes the changing mix of gold production from the three following dynamic components:

i existing gold mines which had produced prior to 1946;
ii gold deposits which had been discovered prior to 1946 but were only brought into production during the 1946-85 period;
iii gold deposits discovered and brought into production during the 1946-85 period.

These three sources may be viewed as the short-term, medium-term, and long-term components of gold supply. Table 7 summarizes gold production of each of these components over the 1946-85 period. The dynamic category into which each deposit falls, based on discovery and production dates, is specified in the listing of deposits in appendix III.

Table 7

SUMMARY OF DYNAMIC COMPONENTS OF GOLD SUPPLY

COMPONENT	GOLD MINES (number)	ORE MINED (million tonnes)	AVERAGE GRADE OF ORE MINED (grams per tonne)	GOLD PRODUCED (tonnes)	OPERATING COST ($ per tonne)	OPERATING COST ($ per ounce)
SHORT-TERM:						
EXISTING MINES	89	309	8.1	2358	40	163
MEDIUM-TERM:						
NEW DEVELOPMENTS	34	52	12.3	599	48	129
LONG-TERM:						
NEW DISCOVERIES	46	37	6.7	234	49	241
TOTAL	169	398	8.5	3191	42	167

The trends in the breakdown of ore mined among these three sources are shown in figure 9 (top panel). Overall, the existing gold mines accounted for 78 percent of the ore produced, the development of known deposits for 13 percent, and new discoveries for the remaining 9 percent. The short-term component contributed such a high percentage because of the relatively high rates of production achieved in the earlier

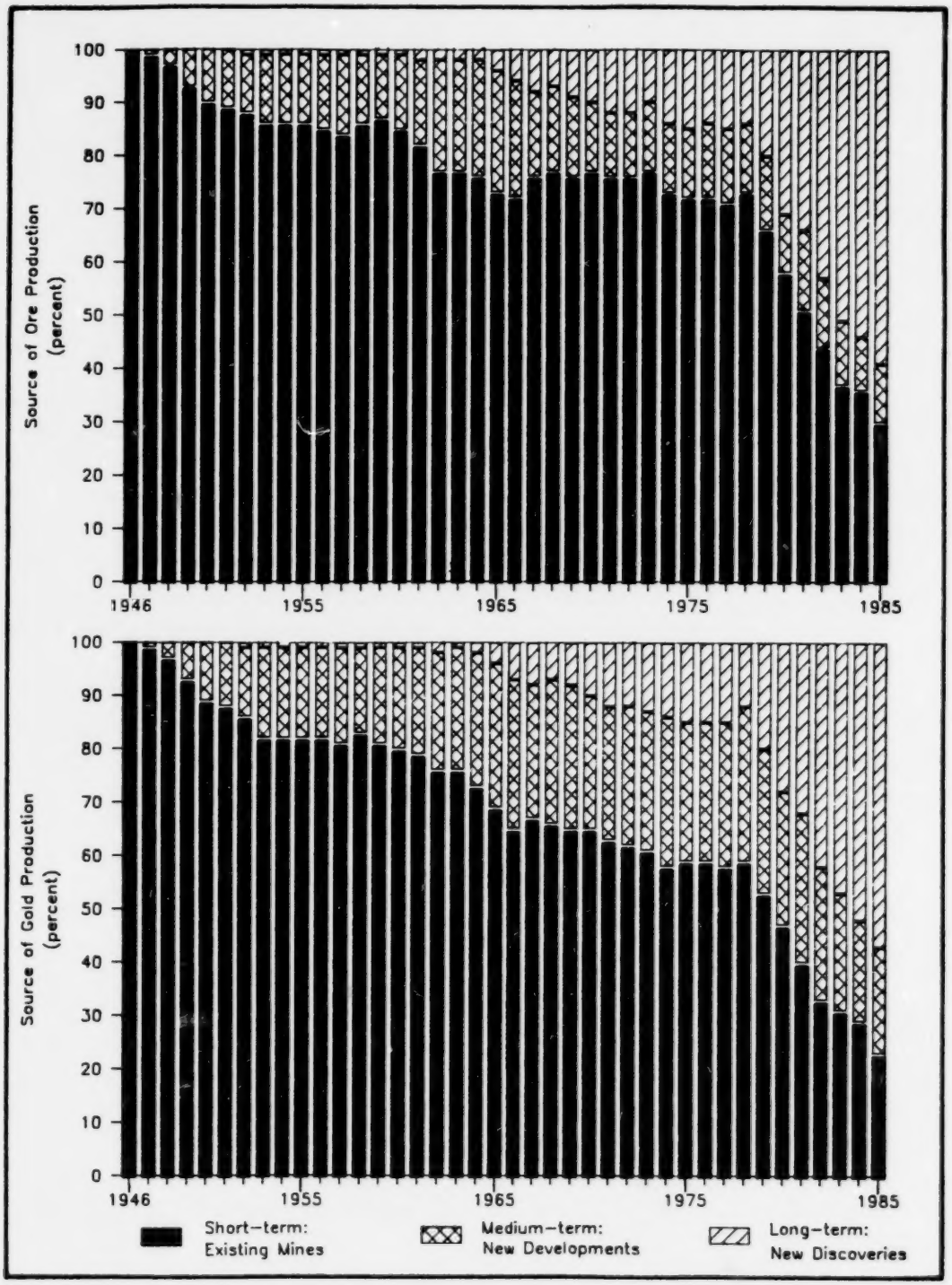

Figure 9. Ore Mined and Gold Produced by Dynamic Supply Components

years of the study period. The medium-term source of supply was most important in the middle years of the timeframe, contributing a maximum of 23 percent of ore mined in 1965. The long-term component is shown to have become increasingly important with time as a source of production. By 1985, gold deposits discovered during the 1946-85 period accounted for 58 percent of the total ore mined, the development of known deposits for 9 percent, while the senior gold mines operating prior to 1946 still contributed 33 percent of ore production.

The trends in the breakdown of gold production among the three components, also show in figure 9 (bottom panel), are generally similar to those outlined above for ore production. Over the entire period, existing mines produced 74 percent of the gold recovered, the development of known deposits accounted for 19 percent, and new discoveries yielded the remaining 7 percent. Once again, the medium-term component made its greatest contribution in the middle years, producing a maximum of 29 percent of total gold recovered in 1978. There was a four-fold increase in gold output from the long-term source of supply between 1980 and 1985. By 1985, 57 percent of Canadian lode gold production came from new discoveries, 20 percent from the development of known deposits, and 23 percent from the senior pre-1946 mines.

Differences between the ore and gold production breakdowns shown in figure 9 mainly reflect deviations in ore grade among the three supply components. It may be noted that the short-term and long-term components account for a greater percentage of ore production than gold production, while the medium-term component contributes a higher percentage of gold production than ore production. This indicates that the average grade of ore mined is somewhat higher for the medium-term deposits.

Weighted average grades calculated for each of the supply components support this inference (table 7). The average grade of ore mined from old existing producers was 8.1 g/t, as compared to 12.3 g/t for mines developed from known deposits, and 6.7 g/t for mines based on new discoveries. The combined weighted average grade for the pre-1946 discoveries (short-term and medium-term components) is 8.7 g/t. This suggests that there has been a reduction in ore grades over time among lode gold deposits in Canada. It should be noted, however, that these grade comparisons are sensitive to the classification of one or two large deposits which could, under a different interpretation of discovery dates, be included in another supply category and, also, are a function of the changing price of gold.

The average operating cost per tonne of ore mined among the three dynamic gold supply components is shown in table 7 to increase from $40

per tonne for the pre-1946 producers, to $48 per tonne for the development of pre-1946 discoveries, to $49 per tonne for the new discoveries. As shown in figure 8 (middle panel), the average operating cost per tonne for all gold mines declined slightly in the 1946-50 interval, remained relatively constant in the $37-38 per tonne range from 1951 to 1972, increased from $43 per tonne in 1973 to $63 per tonne in 1984, and then declined to $56 per tonne in 1985. This trend in the average cost per tonne over the study period reflects the changing mix of the dynamic components of supply and their relative cost characteristics, as well as the changing gold price. The essentially constant costs per tonne during the 1951-72 period reflect the large proportion of production from the lower-cost short-term component. Increases over the 1973-84 period reflect the growing share of more costly production from, first, the medium-term supply component, then, the long-term component. The cost decrease in 1985 is mainly a consequence of the lower price of gold.

The average operating cost per ounce of gold produced for the three sources of supply (table 7) is highest, at $241 per ounce, for the long-term component, while the medium-term component shows the lowest costs, at $129 per ounce, with the average cost associated with the short-term component falling between these two limits at $163 per ounce. The average operating cost per ounce for all gold mines, shown in figure 8 (bottom panel), reflects the relative costs of the dynamic components by first decreasing and then increasing, as the lower-cost medium-term component and then the higher-cost long-term component become increasingly important sources of supply. The large increases in the average operating cost per ounce in more recent years are a reflection of the higher costs per tonne associated with the medium- and long-term supply components coupled with the lower average grades of the new discoveries.

The average operating cost per ounce, as previously discussed, is a function of the cost per tonne of ore mined and the average grade mined. The weighted average grade for the medium-term component, at 12.3 g/t, is considerably higher than the 8.1 g/t grade characterizing the short-term component. This grade difference more than offsets the higher cost per tonne of the medium-term component so that the operating cost per ounce for these mines is lower on average than for the short-term component ($129 versus $163). Although the average cost per tonne for the long-term component is similar to the costs per tonne characterizing the short-term and medium-term mines, the average grade of 6.7 g/t is considerably less than the corresponding values of 8.1 and 12.3 g/t for the existing mines and the new developments respec-

tively. As a result, the average operating cost per ounce for the long-term component ($241) is considerably higher than the unit costs associated with the medium-term and short-term components.

8. INVESTMENT IN GOLD SUPPLY

Repair Expenditures

Repair expenditures represent investment in new equipment and machinery to sustain existing productive capacity.

During the 1946-85 period, about $1.7 billion was spent on this type of investment in the Canadian gold mining sector. Figure 10 (second panel) shows time trends in repair expenditures for the 40-year study period. In the early years, while many mines were striving to regain capacity lost during the war, these expenditures were relatively high. During the 1950s, repair expenditures remained fairly constant at about $3 per tonne of ore mined. At the same time, the total amount spent on equipment repair and replacement diminished as the rate of ore production decreased. The late 1960s showed minor increases but the repair expenditure trend generally continued downward reaching a low of $14 million in 1974. With major gold price increases starting in the mid-1970s, repair expenditures began to increase and, by 1981, $12 per tonne of ore mined was being invested on average in equipment replacement. This large increase in unit investment, from $5 per tonne in 1980, is mainly a result of gold mining companies taking advantage of higher gold prices to initiate machinery equipment and replacement programs neglected during the lean years of the 1950s, 1960s, and 1970s. Repair expenditures reached a peak of $104 million, equivalent to $9 per tonne of ore mined, in 1984, before declining to $80 million in 1985.

Capital Expenditures

Capital expenditures represent investment in new productive capacity including the expansion of existing mining operations and the development of new mines.

During the 1946-85 period, $3.8 billion was spent on capital expenditure items. As shown in the third panel of figure 10, there was a fairly uniform distribution of this investment until about 1978 at which time capital expenditures began to accelerate. Over 65 percent of the total capital expenditures for the 40-year study period have been invested during the six-year interval 1980-85. This reflects the large number of new mines under development, which increased to ten in 1979 and stayed at about that level throughout the 1980-85 period. During the 1950s and

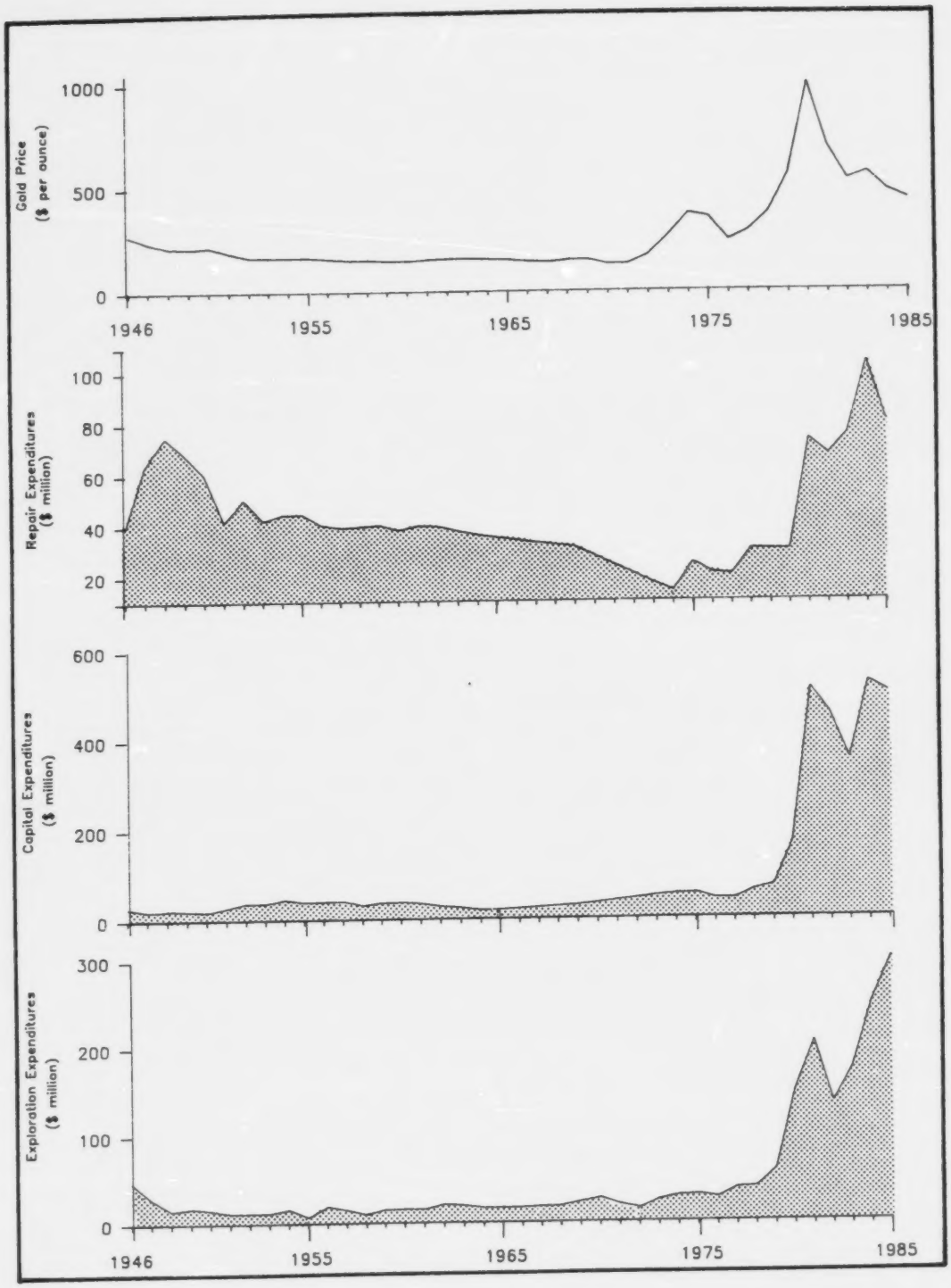

Figure 10. Investment in Gold Supply

1960s, there is a poor correlation between the number of new mine developments and capital expenditures because both were of such a small order.

Exploration Expenditures

Exploration expenditures represent investment in the discovery and delineation of new gold deposits. Figure 10 (bottom panel) shows annual exploration expenditure estimates for the 1946-85 period. Of the total of $2.0 billion, $1.1 billion or 55 percent was invested in 1981-85, the last 5 years of the 40-year study period.

Relatively high exploration expenditures were incurred in 1946 and 1947, but, for the remainder of the time that the price of gold remained fixed (1948-68), investment in gold exploration was more modest and fairly uniform. Only in one year (1962) did gold exploration expenditures exceed $20 million, and only in one year (1955) did they total less than $12 million. From 1968 to 1985, there was a 16-fold increase in exploration investment - from $19 million to $300 million. Until 1983, annual fluctuations in exploration expenditures generally reflect the rise and fall in the price of gold as shown by comparing the top and bottom panels in figure 10. Flow-through share financing weakened that relationship in the mid-1980s.

Investment Synthesis

The relative magnitude of the three investment components - repair, capital, and exploration expenditures - is shown in figure 10.

Over the 1946-85 study period, capital expenditures and exploration expenditures both increased relative to repair expenditures. This reflects the fact that during the 1950s, and 1960s when gold mining in Canada was in decline, the focus was on the survival of existing operations and, thus, repair expenditures accounted for about one half of total investment. During the recovery of the 1970s and the boom of the 1980s, capital expenditures have become relatively important, accounting for approximately 60 percent of total investment by 1985. Exploration expenditures have remained fairly constant as a percentage of investment since the mid-1960s, doubling in dollar terms from 1981 to 1985. This reflects the recently regained prosperity of the gold mining sector.

9. CASH FLOW SYNTHESIS OF GOLD MINING REVENUES AND COSTS

This chapter examines the time distribution of cash flows associated with Canadian gold supply during the study period by combining industry-wide estimates of revenues realized and costs incurred. This leads us to consider the operating viability of gold mining and speculate on the historical rate of return realized on investment in lode gold mining.

Revenue Components

The total value realized from the 3,210 tonnes of gold recovered in Canada during the 1946-85 period amounts to $22.8 billion in 1985 Canadian dollars. Table 8 shows the time distribution of these revenues. The highest annual revenue of $1,022 million was generated in 1980 while the minimum value of $199 million occurred in 1971.

Table 8 also indicates that during the 1948-71 period, an additional $1.3 billion was received by Canadian gold producers in support payments under the terms of the Emergency Gold Mining Assistance Act. This source of revenue peaked at $78 million in 1954.

The revenue available to the gold mining sector over the study period, the sum of the value of gold production and EGMA payments, totalled $24.1 billion.

Cost Components

The four major cost components associated with the Canadian lode gold mining sector during the 1946-85 period are also summarized in table 8. Operating costs, at $17.3 billion, accounted for approximately 70 percent of total costs. The maximum annual operating cost of $663 million occurred in 1950, while the lowest operating cost of $207 million was recorded in 1972. Repair expenditures accounted for $1.7 billion over the study period, with the highest annual value of $103 million recorded in 1984 and the minimum value of $14 million in 1974. Capital expenditures over the 1946-85 period amounted to an additional $3.8 billion with a high of $527 million invested in 1984 and a low of $19 million spent in 1964. Exploration expenditures accounted for $2.0 billion from 1946 to 1985 with a maximum value of $300 million recorded in 1985 and a minimum value of $7 million spent in 1955.

Table 8

CASH FLOW SYNTHESIS OF GOLD MINING REVENUES AND COSTS ($ million 1985)

YEAR	VALUE OF PRODUCTION	EGNA PAYMENTS	TOTAL REVENUES	OPERATING COSTS	REPAIR EXPENDITURES	CAPITAL EXPENDITURES	EXPLORATION EXPENDITURES	TOTAL COSTS	CASH FLOW
1946	653		653	599	40	30	48	716	-63
1947	649		649	582	64	21	29	695	-46
1948	659	62	721	601	75	25	15	716	5
1949	751	71	822	645	68	22	19	754	68
1950	819	50	869	663	60	20	16	759	110
1951	701	53	755	637	42	30	12	721	34
1952	645	52	697	603	50	40	13	706	-9
1953	586	69	655	533	42	38	12	626	29
1954	627	78	705	563	45	48	17	672	33
1955	643	41	685	562	45	40	7	654	31
1956	593	39	633	520	40	42	20	622	11
1957	575	44	619	513	39	43	15	610	9
1958	599	50	650	471	40	32	10	552	97
1959	569	52	621	491	40	39	16	586	35
1960	579	53	633	503	38	40	17	598	35
1961	580	54	634	462	40	36	16	553	81
1962	557	60	617	466	40	29	21	555	62
1963	526	59	585	435	38	25	20	518	67
1964	487	62	550	433	36	19	17	505	44
1965	442	60	502	415	35	22	17	489	14
1966	388	58	445	369	34	24	18	445	1
1967	338	55	393	326	33	27	19	404	-11
1968	297	51	348	294	32	29	19	374	-26
1969	261	45	307	277	31	31	23	363	-56
1970	226	44	270	249	28	36	27	340	-71
1971	199	36	235	221	24	41	18	304	-68
1972	278		278	207	20	46	15	289	-11
1973	381		381	222	17	51	25	315	66
1974	453		453	242	14	55	30	341	112
1975	423		423	263	25	56	25	368	55
1976	296		296	227	21	42	28	318	-22
1977	348		348	232	20	42	31	325	23
1978	438		438	225	30	62	49	366	72
1979	605		605	252	30	73	63	418	187
1980	1022		1022	334	30	170	139	672	349
1981	795		795	428	73	512	199	1212	-418
1982	816		816	493	67	453	194	1207	-391
1983	1004		1004	562	75	352	196	1185	-181
1984	1012		1012	594	103	527	253	1477	-465
1985	980		980	615	80	501	300	1496	-516
TOTAL	22800	1300	24100	17324	1704	3770	2028	24826	-726

It is important to note the time lag between investment and the associated gold supply. Thus, part of the capital expenditures, exploration expenditures and to a lesser extent repair expenditures, invested in more recent years are linked to gold production which will only be realized beyond 1985.

Figure 11 illustrates trends in the relative size of the cost components by decade. While operating costs have been the dominant cost element during the entire study period, the proportion of total costs attributable to operating items has decreased from approximately 85 percent in the decade 1946-55 to 55 percent in the 1976-85 interval. Repair expenditures are shown to have remained relatively constant as a proportion of total costs, while both exploration and capital expenditures have shown major increases, especially in the two decades from 1966-1985. These trends in relative costs reflect the dramatic turnaround in the economic health of the gold mining sector which has taken place during the study period. When the industry was in a survival mode, faced with declining gold prices and production, attention was focused on existing mining operations. Thus, only a small proportion of costs was associated with investment in new development and exploration, and even repair expenditures were cut back. As prices increased in the 1970s and 1980s, the industry shifted into a prosperity and growth mode, with increasing emphasis on equipment replacement, expansion, development, and exploration phases of the gold supply process.

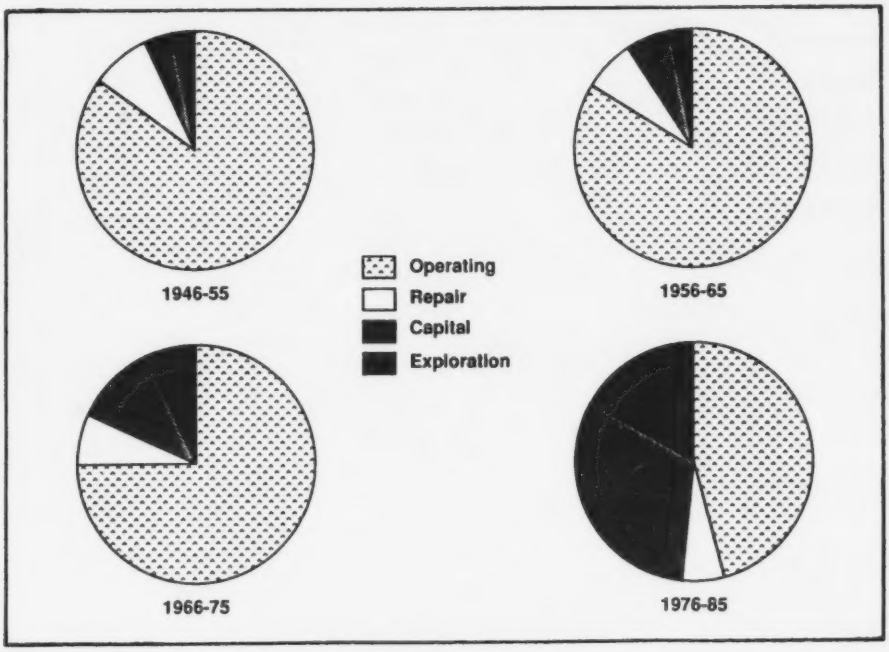

Figure 11. Cost Structure of Gold Supply

Cash Flow Synthesis

Table 8 also shows the synthesis of annual cash flow differences between total revenues and total costs for the 1946-85 period. Total revenues and total costs for the entire study period are remarkably similar, between $24 and $25 billion with the overall cash flow netting out at minus $726 million. In 1946 and 1947, costs exceeded revenue as new mines came on stream and old mines reopened. Thus, negative cash flows were incurred. In 1948, EGMA payments began and, together with the decline in investment, total revenues exceeded total costs each year (except 1952) until 1966, resulting in positive cash flows. Negative cash flows were then recorded each year during the 1966-72 interval, a result of the continuing cost-price squeeze. Many mines eventually succumbed to the increasing costs and closed. The 1973-80 period saw a sharp increase in revenue as the gold price soared and, as a result, revenues generally exceeded costs, generating positive cash flows in all years with the exception of 1976. The 1981-1985 period has witnessed a major increase in total costs which exceeded revenues in all five years. Healthy positive differences are shown between revenues and operating costs. The negative cash flows reflect increased capital investment and exploration expenditures which, to the extent they are successful, will translate into increased gold supply and revenues in the years to come.

Operating Viability

To examine the operating viability of gold mining over the study timeframe, a comparison is made here between the price of gold and mine operating costs per ounce, disaggregating the revenue and operating cost totals presented in figure 8. Over the 1946-85 period, 80 percent of Canadian lode gold was produced at an operating cost less than the gold price. Figure 12 (middle panel) shows that the proportion of economic gold production (unit cost less than price) varied from a high of 98 percent in 1982 to a low of 53 percent in 1967.

During the 1946-67 interval when the nominal U.S. dollar gold price was fixed at $35 per ounce, a downward trend in the proportion of gold produced at an operating cost less than the price of gold was experienced, falling from 90 percent in 1946 to 53 percent in 1967. Within this overall decline, however, were several years when the percentage of profitable gold production increased. These increases are associated with devaluations in the Canadian dollar relative to the U.S. dollar, resulting in increased Canadian dollar gold prices. The rise in gold

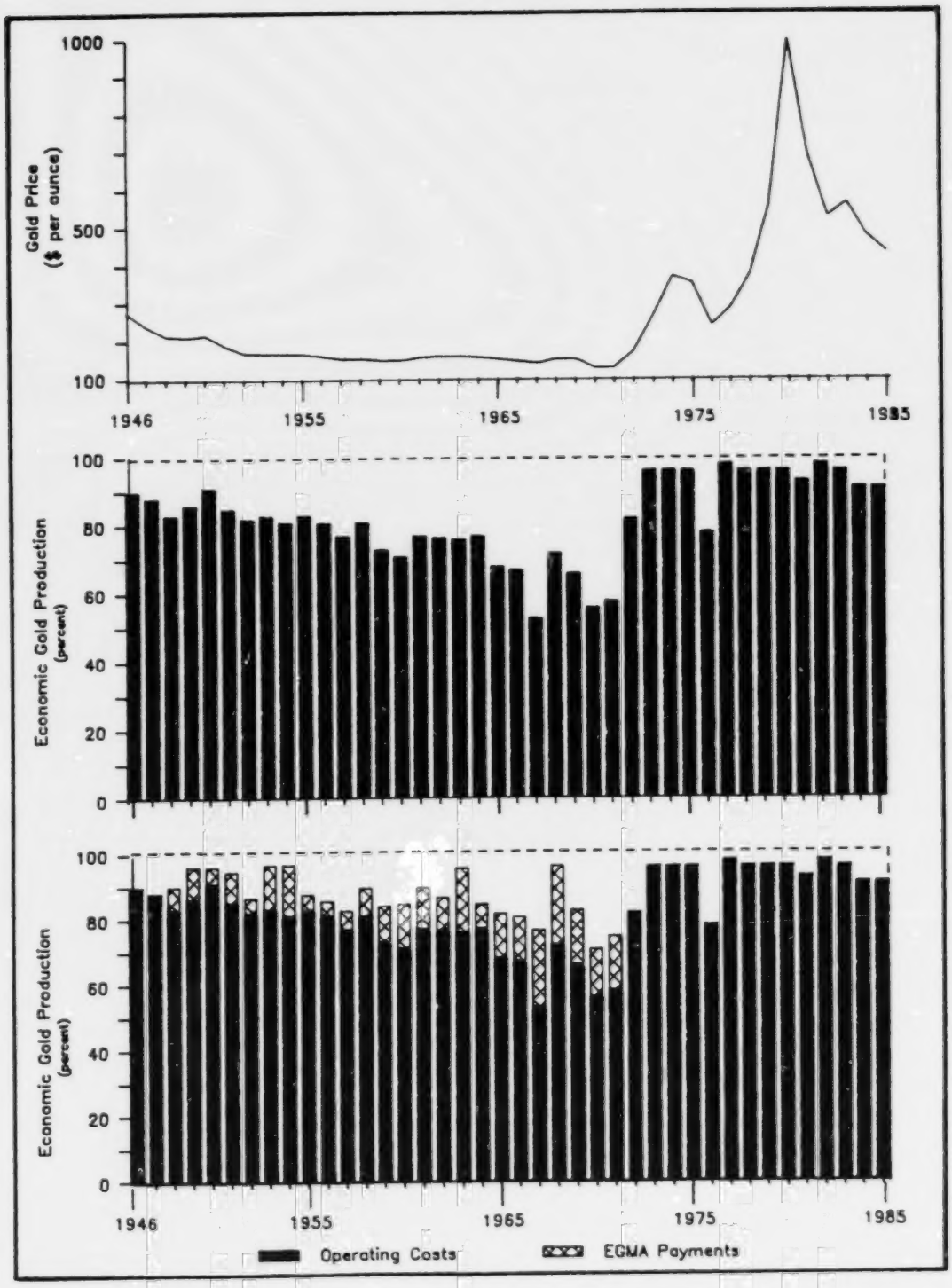

Figure 12. Gold Produced at an Operating Cost Less than the Price of Gold

prices associated with the establishment of the two-tier gold pricing system in 1968 gave the gold mining sector a reprieve. Over 70 percent of the gold supply at this time was produced at a cost of less than the gold price as shown in figure 12. This proportion was reduced to less than 60 percent in 1970-71 as gold prices reached an all-time low. During the 1972-85 period, rising gold prices generally increased the proportion of profitable gold production to over 90 percent each year with the exception of 1976 when the gold price fell by nearly one third.

The preceding analysis of the profitability of gold mining does not take into account the cost assistance provided from 1948 to 1971 by EGMA. In order to include this assistance in the analysis, EGMA payments per ounce (table 5) are considered to have effectively increased the gold price. For example, in 1948 the price of gold (in constant 1985 dollars) was $214 per ounce and EGMA payments averaged $20 per ounce. Thus the revenue received by the gold mines or, in other words, the effective gold price, was $234 per ounce. These EGMA gold price increments meant that more gold was produced at an operating cost less than the gold price than would otherwise have been the case. In fact, this was the specific intent of EGMA policy. For example, during the assistance period (1948-71), 77 percent of lode gold was produced at an operating cost below the gold price. When EGMA payments are taken into account, the proportion of economic gold supply increases to 88 percent. Similarly, for the entire 1946-85 study period, the inclusion of EGMA increased the amount of gold produced at an operating cost less than the gold price from 80 to 89 percent. Figure 12 (bottom panel) shows the effect of EGMA on economic gold production on a yearly basis. Without considering EGMA assistance, more than 20 percent of the gold was produced at costs above the gold price in 14 of the 25 years from 1948 to 1972, and in six of those years 30 percent of the gold produced incurred costs exceeding the price of gold. With assistance, however, there were only three years in which 20 percent or more of the gold production had operating costs exceeding the gold price, and in none of these cases was the figure as high as 30 percent.

Rate of Return on Investment

According to Busschau's[12] theory of gold supply, gold should be produced to the point where the marginal rate of return on investment just equals the cost of capital. The weighted average cost of capital for

12. W.J. Busschau, The Theory of Gold Supply, Oxford University Press, London, 1936.

investment in Canadian gold supply over the study timeframe is most likely within the range of 5 to 10 percent. Thus, according to Busschau, the marginal rate of return on investment should approximate this cost-of-capital range. However, considering the costs and revenues documented in this study for the 1946-85 period, as summarized in table 8, the average rate of return on investment is apparently close to zero. In other words, over the 40-year study period, total revenues and total costs just about balance without any allowance for the cost of capital. And if the average return is close to zero, the marginal return must be decidedly negative.

The difference between the investment margin predicted by Busschau and that implied by the empirical evidence in table 8 may be explained in part by the time lag which exists between investment in gold mining and revenues generated as a result of that investment. Two aspects of this time lag are relevant here. The first concerns the investment made in more recent years which is directly associated with future gold supply. The second relates to the revenues realized in the early years of the study which are linked to exploration costs incurred and mine capacity established and maintained prior to 1946.

A realistic approach to appraising the rate of return on investment in lode gold mining over the study period, then, would consider these two factors. It is arguable, however, whether the productive gold mining assets inherited by our 1946-85 study period are less valuable than the legacy of investment bequeathed in 1985 to future years. While determination of the profitability of gold mining lies outside the scope of the present study, these initial indications are cause for concern. An analysis of the historical rate of return on investment for the Canadian gold mining sector which properly takes the time lags between exploration expenditures, development investment, and production into account would be an interesting area for further research.

10. CONCLUSIONS

When we stand back and reflect on the specific trends in gold production, employment, operating costs, and investment examined in this paper, the big picture which emerges is that of a long economic cycle of 50-55 years duration.[13] Furthermore, it is interesting to note that the long wave of prosperity and depression in gold supply, controlled by the gold price, runs counter to the long business cycle which characterizes overall economic activity and other types of mining endeavour. While these economic phenomena may be generally observed in the western world, they are viewed here in the specific context of gold supply in Canada during the 1946-85 period.

An upward phase of the long wave was initiated in 1934, well before the start of our 40-year study period, when the U.S. government devalued the dollar by increasing the price of gold from $20.67 to $35 per ounce. Occurring in the midst of the great depression, this revaluation had a highly stimulating worldwide effect on primary gold supply.

In Canada, the momentum of this long wave of prosperity carried over into the immediate postwar years, the start of our study period. The number of lode gold mines rose to a peak of 91 in 1948-49. Until 1952, gold remained the perennial leader in value among all metals (and mineral commodities) produced in Canada.

Following the initial impetus of $35-per-ounce gold, however, the fixed nominal price and cost inflation through the late 1940s, 1950s, and 1960s combined to force a steady decline in gold mining activity. While Canada generally experienced a long period of rapid and stable economic growth between 1950 and 1970, and the mineral sector otherwise flourished, gold mining was increasingly forced into a survival mode. The economic trends examined in this paper document both the actions taken to cope with the depressed conditions and the inevitable consequences.

The actions taken were as follows:

- cut-off grades were systematically raised;
- production was concentrated in fewer, larger mining operations to realize economies of scale;

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13. For further information on economic cycles, including the long cycle or Kondratieff wave, the interested reader is referred to: M. Lamontagne, Business Cycles in Canada: the Postwar Experience and Policy Directions, Canadian Institute for Economic Policy, 1984; and C.A. Grandison, "Economic Cycles as a Tool in Business Forecasting", CIM Bulletin, December 1976, pp. 58-62.

- several higher quality deposits were developed to production;
- little exploration was carried out and development of reserves was cut back to the bare minimum;
- a major government subsidy program, Emergency Gold Mining Assistance, was enacted to ease the impact of mine closures on the dependent gold mining communities.

Nevertheless, the inescapable consequences of the cost-price squeeze continued, extending well into the 1970s:

- the number of producing gold mines in Canada fell from 91 in 1949 to 17 in 1977;
- gold's ranking among metals in terms of value of production had slipped from the first to sixth place by 1968;
- Canadian gold production declined from 120 tonnes in 1952 to 32 tonnes in 1980;
- employment in gold mining fell from 22,900 in 1947 to 4,600 in 1977.

The basis for the recovery of gold mining in Canada which has subsequently occurred was the establishment of an open market for gold transactions in the late 1960s, whereby the price is free to fluctuate with the forces of supply and demand. The spectacular rise in gold market prices which followed has provided a great worldwide incentive for gold exploration, development and mining similar to that which occurred in the 1930s. A depressed industry from the 1950s and 1960s has once again become a positive force for investment and growth. This new upward phase of the long economic cycle has taken approximately 15 years to build to the record levels of activity being experienced in the mid-1980s, about 50 years after the last crest in the 1930s. It is interesting to note that this period of recovery in gold supply corresponds more generally to a troubled time of economic recessions, high unemployment, and otherwise depressed international mineral market conditions - further evidence of the counter-cyclical nature of gold mining.

In Canada, we are just starting to realize the results of the record levels of investment now taking place. The number of producing gold mines increased from 17 in 1977, to 43 in 1985, to an estimated 47 in 1987. Gold, which by 1983 had returned to third place among metals in value of production, has now (in 1987) most likely regained first place. Canadian gold production increased from 32 tonnes in 1980, to 69 tonnes in 1985, to an estimated 95 tonnes in 1987, while gold mine employment increased from 4,600 in 1977 to 7,900 in 1985. We estimate that in 1987

approximately $800 million is being expended on gold exploration in Canada, and about $1 billion is currently being invested in the expansion of existing operations and the development of 15 new gold mines. Several factors are fueling these unprecedented levels of activity: the intense desire of investors to own gold mining assets; flow-through share financing; a welfare interest in fully employing available geoscience, engineering, consulting, and contracting skills; and the current (October 1987) spot price of over C$600 per ounce of gold.

One thing is perfectly clear - we are once again riding the crest of the economic wave of gold prosperity. The key question is, how long will it last? At the end of the day, perhaps the money spent and the people employed do not count as much as the wealth being created for Canadian society. In attempting to look ahead at what the future may have in store for gold supply in Canada through the 1990s to the turn of the century and beyond, we suggest that it is a relevant and sobering exercise to reflect on the long historical economic wave which has brought us to our present state of good fortune.

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APPENDIX I

NOTE ON UNITS, DEFINITIONS, AND DATA SOURCES USED

Units

Physical measures of gold supply are expressed in metric units.

Rate of Gold Production: tonnes; 1 tonne = 32,151 troy ounces;

Size of Ore Reserves and Rate of Ore Production: tonnes; 1 tonne = 1,000 kilograms = 1.102 short tons.

Grade of Ore Reserves and Ore Mined: grams per tonne (g/t); 1 g/t = 0.029167 ounces per tonne = 0.026467 ounces per short ton.

Monetary units are expressed in constant 1985 Canadian dollars unless otherwise specified.

Definitions

Gold may be produced by lode gold mines, placer mining operations, or recovered as a by-product from base metal and nickel mines. Lode gold mines, the focus of this paper, are associated with deposits in consolidated rock (typically quartz veins) from which gold is the prime contributor to value of production.Base metals are not normally present in economically recoverable amounts.

Cumulative statistics aggregated from data which have been compiled on a mine-by-mine basis are summarized in several ways in the study. For example, the following statistics for tonnes of ore mined are used to characterize production in 1946:

Number of mines in production: 78
Total tonnes mined: 9,504,911
Mean tonnes per mine: 121,858

Key statistics by mine -
Median: 83,485
Lower-Decile: 8,167
Lower-Quartile: 25,408
Upper-Quartile: 146,098
Upper-Decile: 280,399

Key statistics by tonne -
Median: 196,007
Lower-Decile: 67,151
Lower-Quartile: 104,356
Upper-Quartile: 388,385
Upper-Decile: 588,076

The mean value represents the average rate of production and is obtained by dividing the total tonnes mined (9,504,911) by the number of mines in production (78). With respect to ore grade and operating cost parameters, a "weighted" mean value is also calculated. These weighted averages are obtained by weighting the mine-specific values by the tonnes of ore produced in each case.

The key statistics by mine may be interpreted as follows. One half of the mines had a lower rate of production than the median value by mine of 83,485 tonnes, and one half achieved a higher production rate. The lower-decile statistic denotes that 10 percent of the mines produced less than 8,167 tonnes while the remaining 9 percent mined more than this value. With reference to the upper-decile, 10 percent of the mines produced more than 280,399 tonnes of ore. The quartile statistics have similar meaning, considering 25 percent rather than 10 percent of the number of mines in production.

With respect to the key statistics by tonne, the median value of 196,000 tonnes denotes that one half of the total tonnes were produced from gold mines with more (and one half from gold mines with less) than this annual production rate. Similar meanings are associated with the decile and quartile statistics. For example, the upper quartile value shows that 75 percent of the tonnes mined were derived from mines with a rate of production less than 388,385 tonnes.

Data Sources

Most of the aggregate data for the gold mining sector were obtained from Statistics Canada publications. These include annual data on employment (STATS CAN 26-209, 26-233 series), value of production (STATS CAN 26-209, 26-201 series), and investment statistics (STATS CAN 61-206 series). The Emergency Gold Mining Assistance Act published a yearly report from 1948 to 1976 from which cost assistance figures were assembled.

The statistical averages and distributions presented in the paper have been tabulated from a deposit-specific data base compiled from various sources. In many cases it has been possible to obtain the same information from several sources and the most consistent data has been used wherever possible. On the other hand, in a few cases, no data whatsoever were available. Given the small number of cases where this occurred, best estimates and interpolations have been used with no apparent detrimental affect on the accuracy of the derived statistics.

By far the most important source material for the deposit-specific data were company annual reports for the years 1946-1985. Until 1960, Statistics Canada publication 26-201, "Gold Mining Statistics", provided detailed tables of operating statistics for individual mines and much useful information was obtained from this source. The National Mineral Inventory cards maintained by Energy, Mines and Resources Canada were also a key source of information providing detailed summaries of past and present producers. Other sources include: The Canadian Mines Yearbook, Financial Post Corporation Index Cards, Canadian Mines Handbook, The Northern Miner, Canadian Mining Journal, Engineering & Mining Journal, various provincial government and investment firm reports, as well as some information obtained directly from mining companies. The mine-specific data upon aggregation was found to correspond closely with Statistics Canada aggregate data indicating that the data base has a high degree of reliability.

APPENDIX II

CANADIAN GOLD SUPPLY STATISTICS

Table 9

SIZE AND GRADE OF ORE RESERVES

YEAR	SIZE OF ORE RESERVES (thousand tonnes)	GRADE OF ORE RESERVES (grams per tonne)
1946	60586	7.4
1947	64291	7.3
1948	66647	7.5
1949	66187	7.3
1950	71867	7.2
1951	69469	7.7
1952	66078	8.2
1953	63235	8.4
1954	61039	8.6
1955	61408	8.8
1956	59771	9.7
1957	53716	10.1
1958	49856	10.3
1959	46380	10.1
1960	45608	10.0
1961	41936	10.1
1962	41309	9.7
1963	38026	9.7
1964	35764	9.8
1965	36104	9.4
1966	32352	9.2
1967	28833	9.3
1968	28695	8.9
1969	24928	9.1
1970	20345	9.5
1971	16512	10.0
1972	16918	9.8
1973	19343	8.9
1974	48609	8.6
1975	48206	8.0
1976	40748	8.3
1977	33312	7.9
1978	28364	8.0
1979	39664	6.9
1980	42590	6.4
1981	66821	5.6
1982	73185	5.8
1983	107880	5.1
1984	93083	5.5
1985	159537	7.1

Table 10

KEY STATISTICS: RATE OF ORE PRODUCTION
(thousand tonnes)

YEAR	TOTAL PRODUCTION	NUMBER OF MINES	MEAN RATE	KEY STATISTICS BY MINE					KEY STATISTICS BY TONNE				
				MEDIAN	LOWER DECILE	LOWER QTILE	UPPER QTILE	UPPER DECILE	MEDIAN	LOWER DECILE	LOWER QTILE	UPPER QTILE	UPPER DECILE
1946	9505	78	122	83	8	25	146	280	196	67	104	388	558
1947	10288	86	120	83	4	28	142	270	200	68	100	365	688
1948	12082	91	133	93	7	37	143	312	230	71	117	418	761
1949	14333	91	158	101	11	41	165	404	302	88	129	537	998
1950	15254	85	179	117	15	48	169	512	347	97	140	598	678
1951	14942	83	180	113	16	46	174	502	337	102	139	609	841
1952	14844	74	201	128	26	64	190	552	378	103	157	623	974
1953	13664	68	201	124	15	60	213	558	512	103	156	596	751
1954	14451	63	229	132	30	79	255	597	470	108	167	644	1725
1955	14670	60	244	151	45	98	267	606	485	118	163	652	952
1956	13091	58	226	139	30	84	241	581	493	113	172	657	954
1957	12971	52	249	151	48	93	279	614	506	113	168	662	946
1958	13024	53	246	161	50	94	261	624	450	111	177	684	1015
1959	12673	52	244	159	36	74	260	642	469	110	179	683	990
1960	13000	53	245	157	36	83	303	640	412	120	179	686	1031
1961	12795	52	246	150	35	93	268	643	456	128	181	666	979
1962	12182	50	244	149	36	100	298	642	388	113	172	649	928
1963	11362	48	237	153	31	109	294	626	399	125	166	633	816
1964	11087	50	222	142	26	89	293	566	402	111	167	593	701
1965	10224	52	197	132	10	69	240	519	400	105	154	557	696
1966	9333	48	194	121	5	49	321	497	384	100	191	516	649
1967	8441	42	201	144	7	59	301	465	349	119	191	462	624
1968	7713	38	203	144	16	43	306	485	344	111	195	479	642
1969	7493	35	214	158	10	41	305	543	353	142	209	536	633
1970	6624	31	214	168	23	61	288	554	299	119	198	513	628
1971	5858	28	209	132	17	44	307	600	340	103	238	579	634
1972	5440	20	272	240	60	105	440	625	385	120	240	567	643
1973	5080	20	254	184	41	91	424	612	442	119	230	561	683
1974	4991	21	238	177	42	82	397	603	414	96	216	514	689
1975	5326	20	266	219	29	81	427	629	426	126	269	557	760
1976	5354	18	297	257	24	69	493	679	491	154	307	591	873
1977	5449	17	321	270	33	85	439	741	435	157	328	609	1000
1978	5555	17	327	273	11	101	449	751	450	181	325	603	1004
1979	5434	22	247	175	21	44	364	554	385	109	270	549	897
1980	5620	25	225	192	8	34	335	509	355	122	258	578	919
1981	6260	32	196	103	7	23	346	486	373	103	242	508	777
1982	8236	37	223	179	20	38	295	480	325	119	237	621	925
1983	9835	43	229	188	18	57	301	458	316	152	212	549	983
1984	11513	45	256	186	51	64	338	654	393	117	241	784	1120
1985	11758	43	273	198	30	67	339	742	385	145	218	838	1083

Table 11

KEY STATISTICS: GRADE OF ORE MINED
(grams per tonne)

	KEY STATISTICS BY MINE						KEY STATISTICS BY AMOUNT OF GOLD					
YEAR	MEAN	MEDIAN	LOWER DECILE	LOWER QTILE	UPPER QTILE	UPPER DECILE	MEAN	MEDIAN	LOWER DECILE	LOWER QTILE	UPPER QTILE	UPPER DECILE
1946	10.1	9.1	4.0	5.8	13.4	17.3	8.2	9.0	5.1	7.0	11.9	16.1
1947	10.5	9.2	4.1	6.2	13.7	16.7	8.6	9.4	5.2	7.2	13.2	16.0
1948	11.2	9.5	4.3	6.2	14.1	20.1	8.4	9.1	4.7	7.1	13.0	16.4
1949	10.1	8.9	3.9	6.1	13.2	16.3	8.1	9.1	4.4	6.5	12.9	15.2
1950	11.0	9.6	3.7	6.5	13.3	20.1	8.2	9.3	4.2	7.1	12.8	15.0
1951	10.5	9.2	3.6	6.4	13.3	18.8	8.2	9.5	5.5	7.2	12.8	16.6
1952	10.8	9.6	4.1	6.3	13.4	19.3	8.6	9.9	5.8	7.3	12.7	15.6
1953	11.1	9.9	3.8	6.1	13.8	18.7	8.6	9.8	4.8	6.7	13.6	19.2
1954	11.3	9.5	4.3	6.3	13.9	21.4	8.6	9.7	4.9	7.1	12.7	19.1
1955	11.2	9.0	3.7	6.1	13.4	21.2	8.8	9.7	5.0	8.2	13.4	19.9
1956	12.7	9.8	4.2	6.6	15.1	24.5	9.4	10.0	5.6	8.1	14.7	20.4
1957	12.5	9.5	4.2	6.7	16.6	22.5	9.7	10.7	5.5	8.3	15.9	22.4
1958	12.6	9.3	4.4	6.0	15.1	23.9	9.9	10.8	5.9	8.4	14.9	23.7
1959	12.3	9.7	4.6	6.5	14.4	27.2	10.0	12.1	5.8	8.6	15.2	26.5
1960	12.4	8.7	4.5	6.2	15.4	25.2	10.0	11.3	5.5	8.1	16.9	26.7
1961	11.8	8.7	4.4	6.3	13.1	24.0	9.8	11.1	5.9	7.5	14.7	25.1
1962	11.1	7.9	4.3	5.4	12.6	23.7	9.5	11.3	5.0	7.1	17.6	24.6
1963	11.3	8.1	4.3	5.3	14.2	23.7	9.6	11.0	5.2	6.8	18.9	23.9
1964	11.6	9.2	4.4	5.4	16.6	22.3	9.4	10.6	4.7	6.6	17.5	23.7
1965	11.4	8.9	4.3	5.2	16.2	23.6	9.5	10.7	5.1	8.0	19.0	24.6
1966	12.8	10.6	4.1	6.3	16.5	24.5	9.5	10.8	5.2	8.7	20.3	24.3
1967	12.3	9.7	4.5	6.5	17.9	23.0	9.4	10.0	4.5	7.0	17.9	23.4
1968	12.4	9.2	4.8	6.2	18.3	23.5	9.4	10.8	4.8	7.3	18.5	23.2
1969	11.3	10.0	4.7	5.7	16.6	22.4	9.0	10.0	4.8	6.3	17.5	22.6
1970	12.0	9.2	4.5	6.2	16.7	24.5	9.3	10.3	4.5	6.2	20.5	23.5
1971	13.2	10.4	4.7	6.8	20.6	24.8	9.8	10.4	4.6	8.2	20.9	23.9
1972	14.3	10.4	4.6	5.2	21.9	33.3	9.9	10.6	4.6	6.7	23.1	25.0
1973	12.3	11.0	3.9	5.0	17.9	24.3	9.2	12.2	4.0	5.4	18.6	24.0
1974	10.7	7.8	3.8	5.2	15.1	24.3	8.0	8.8	3.8	5.6	20.0	25.2
1975	10.5	7.7	3.7	5.4	15.6	22.7	7.5	7.6	3.7	5.3	17.6	21.2
1976	11.9	9.1	3.8	5.7	18.9	23.1	7.7	7.1	3.6	4.9	19.7	22.5
1977	11.4	8.7	3.4	5.3	17.8	23.7	7.4	7.0	3.3	5.8	20.1	22.8
1978	9.7	6.5	2.6	4.9	15.6	20.3	7.0	6.7	3.1	4.9	18.7	20.7
1979	8.9	6.8	6.5	4.9	12.1	20.0	6.7	6.9	3.1	5.0	15.9	21.6
1980	8.3	6.7	3.2	4.0	11.2	18.0	6.2	7.0	2.7	4.0	16.5	20.9
1981	7.6	6.0	2.5	3.7	11.7	15.6	5.9	6.4	3.0	4.4	14.4	19.0
1982	7.9	6.3	2.4	4.3	11.0	18.8	6.3	6.5	3.0	4.8	12.0	19.9
1983	7.8	6.0	3.0	4.4	12.3	16.7	6.4	6.4	3.5	5.1	12.4	19.1
1984	7.5	5.0	2.6	3.6	8.3	18.1	6.1	6.1	3.3	4.8	12.6	18.9
1985	7.9	5.9	2.8	4.2	10.6	15.0	6.2	6.8	3.2	4.7	11.1	17.5

Table 12

KEY STATISTICS: RATE OF GOLD PRODUCTION (kilograms)

YEAR	TOTAL PRODUCTION	NUMBER OF MINES	MEAN RATE	KEY STATISTICS BY MINE					KEY STATISTCS BY AMOUNT OF GOLD				
				MEDIAN	LOWER DECILE	LOWER QUARTILE	UPPER QUARTILE	UPPER DECILE	MEDIAN	LOWER DECILE	LOWER QUARTILE	UPPER QUARTILE	UPPER DECILE
1946	73837	78	947	644	56	286	1104	1645	1316	504	874	3835	5371
1947	83781	86	974	666	44	264	1148	1826	1334	582	886	4395	5692
1948	96194	91	1057	734	53	327	1253	2084	1418	560	980	4522	5847
1949	109879	91	1207	771	131	339	1471	2488	1760	653	1141	4774	7987
1950	117147	85	1378	974	149	448	1617	2837	2009	650	1222	4488	8460
1951	115100	83	1387	837	149	448	1543	2914	2043	731	1247	4336	7384
1952	119938	74	1621	1194	208	594	2031	3154	2292	774	1390	4824	6560
1953	109297	68	1607	1222	131	666	1863	3471	2314	781	1331	4998	5950
1954	115799	63	1838	1328	308	700	2028	3903	2432	1051	1453	5325	9266
1955	120294	60	2005	1434	339	921	2168	3994	2488	1042	1533	5384	8955
1956	115114	58	1985	1365	218	690	2314	4242	2774	1036	1564	6087	9723
1957	117211	52	2254	1515	491	843	2634	5045	2868	1138	1888	5816	10404
1958	120803	53	2279	1474	426	802	2681	4762	3319	1095	1922	6152	11418
1959	119251	52	2250	1359	267	802	2678	5300	3337	1107	2043	7107	11185
1960	121389	53	2290	1334	274	656	2575	5316	3505	1160	1984	7011	12102
1961	116870	52	2247	1459	299	669	2644	5275	3300	1182	1848	7101	11066
1962	108034	50	2161	1406	417	659	2591	5312	3135	840	1872	7235	9157
1963	102432	48	2134	1521	156	750	2650	5511	3029	927	1820	6109	7717
1964	97897	50	1958	1313	292	619	2370	5455	2799	946	1732	5533	8270
1965	90945	52	1749	1107	103	566	2050	5017	2833	886	1617	5580	7679
1966	82691	48	1723	1194	59	575	2333	5325	2759	877	1561	5567	5947
1967	75212	42	1791	1502	93	594	2519	4967	2833	886	1583	5070	5748
1968	67724	38	1782	1505	177	379	2641	5599	2858	1014	1630	5602	5651
1969	62773	35	1794	1281	96	662	2678	5023	2684	908	1624	4883	5580
1970	57467	31	1854	1263	137	806	2743	5095	2743	908	1540	4678	5561
1971	53529	28	1912	1428	131	635	2837	4501	2837	1067	983	3925	5371
1972	49792	20	2490	2351	868	1185	3260	4516	2837	1176	2134	4127	4843
1973	43699	20	2185	1938	579	930	3151	4553	3054	1005	1947	3969	5039
1974	37232	21	1773	1244	299	718	2560	3689	2538	967	1434	3443	4697
1975	37445	20	1872	1723	255	756	2697	3596	2510	1045	1723	3200	4382
1976	37827	18	2101	1963	227	846	3039	3919	2818	1160	1963	3521	4386
1977	37406	17	2200	1975	417	933	2911	4308	2743	1191	1897	3375	4653
1978	36441	17	2144	2124	78	1229	2787	4286	2597	1611	2025	3608	4569
1979	34237	22	1556	1353	100	429	2171	3176	2165	883	1589	2998	4277
1980	32482	25	1299	1008	78	152	1757	2833	1813	880	1558	2793	4305
1981	34861	32	1089	547	25	196	1711	2432	2134	495	1253	2700	4644
1982	48111	37	1298	778	72	283	1876	2728	2012	703	1356	2970	5319
1983	58045	43	1350	930	140	373	1904	3384	2047	638	1298	3894	5219
1984	64706	45	1438	816	168	355	1913	3328	2490	756	1367	4350	5838
1985	68587	43	1595	951	174	605	2178	3580	2403	699	1528	4230	6094

Table 13

EMPLOYMENT IN GOLD MINING

YEAR	EMPLOYMENT		EMPLOYMENT IN GOLD MINES AS A PERCENTAGE OF ALL METAL MINES	LODE GOLD MINES	
	LODE GOLD MINES (number)	ALL METAL MINES (number)		ORE MILLED (thousand tonnes)	TONNES MILLED PER EMPLOYEE
1946	21973	35445	62	9505	433
1947	22906	39334	58	10288	449
1948	22566	41890	54	12082	535
1949	22358	46181	48	14333	641
1950	22491	47697	47	15254	678
1951	22126	52271	42	14942	675
1952	20757	55338	38	14844	715
1953	18751	51711	36	13664	729
1954	18479	51599	36	14451	782
1955	18032	53364	34	14670	814
1956	17031	57564	30	13091	769
1957	16911	62554	27	12971	767
1958	16811	61999	27	13024	775
1959	16777	68871	24	12673	755
1960	16542	61882	27	13000	786
1961	15788	59597	26	12795	810
1962	15211	59317	26	12182	801
1963	14408	58778	25	11362	789
1964	13807	57648	24	11087	803
1965	12979	60942	21	10224	788
1966	11560	61670	19	9333	807
1967	10319	61728	17	8441	818
1968	8983	63369	14	7713	859
1969	8208	60550	14	7493	913
1970	7175	66590	11	6624	923
1971	6145	66012	9	5858	953
1972	5575	61994	9	5440	976
1973	5603	66134	8	5080	907
1974	5665	70038	8	4991	881
1975	5798	69161	8	5326	919
1976	5051	68269	7	5354	1060
1977	4645	67242	7	5449	1173
1978	4943	56447	9	5555	1124
1979	5013	58960	9	5434	1084
1980	5839	66118	9	5620	962
1981	6809	68712	10	6260	919
1982	7350	61503	12	8236	1121
1983	7956	52194	15	9835	1236
1984	8450	52683	16	11513	1362
1985	7862	48672	16	11758	1496
			22 average		838 average

Table 14

AGGREGATE GOLD MINE OPERATING COSTS
($ million 1985)

YEAR	WAGES AND SALARIES	FUEL AND ELECTRICITY	MATERIALS AND SUPPLIES	TOTAL OPERATING COSTS
1946	352	47	200	599
1947	328	43	211	582
1948	344	40	216	601
1949	353	42	250	645
1950	360	44	259	663
1951	346	39	252	637
1952	334	37	232	603
1953	295	33	204	533
1954	313	34	216	563
1955	308	34	219	562
1956	292	32	196	520
1957	290	31	192	513
1958	288	32	150	471
1959	288	32	171	491
1960	289	31	183	503
1961	284	31	147	462
1962	277	29	159	466
1963	262	28	146	435
1964	258	28	146	433
1965	243	27	145	415
1966	220	24	125	369
1967	199	22	105	326
1968	178	18	97	294
1969	165	18	94	277
1970	147	18	84	249
1971	128	16	76	221
1972	122	14	70	207
1973	126	14	82	222
1974	141	14	87	242
1975	154	15	93	263
1976	137	15	76	227
1977	132	17	83	232
1978	139	20	66	225
1979	146	22	85	252
1980	178	26	130	334
1981	211	34	183	428
1982	243	46	204	493
1983	270	54	238	562
1984	298	60	236	594
1985	283	61	271	615
TOTAL	9721	1222	6381	17324

Table 15

KEY STATISTICS: OPERATING COST PER TONNE OF ORE MINED ($ 1985)

YEAR	KEY STATISTICS BY TONNE					
	MEAN	MEDIAN	LOWER DECILE	LOWER QTILE	UPPER QTILE	UPPER DECILE
1946	51	51	26	31	60	79
1947	49	50	24	25	56	76
1948	46	46	23	30	52	70
1949	41	41	17	26	50	65
1950	41	35	19	25	49	63
1951	37	32	17	24	48	61
1952	37	31	19	22	47	62
1953	37	31	19	21	48	59
1954	37	29	18	22	45	60
1955	36	29	18	24	44	56
1956	37	31	17	25	45	58
1957	37	30	17	25	45	59
1958	37	32	17	25	44	59
1959	38	32	17	25	46	53
1960	37	34	17	24	45	58
1961	38	34	17	25	46	57
1962	38	35	16	24	47	56
1963	38	38	17	23	49	56
1964	38	39	18	23	48	54
1965	38	39	19	24	48	55
1966	38	41	19	22	45	56
1967	38	37	19	21	46	63
1968	38	29	19	22	49	60
1969	37	28	20	22	47	59
1970	38	27	19	20	52	60
1971	37	27	17	21	49	56
1972	38	28	17	22	49	56
1973	43	34	23	28	49	65
1974	47	35	27	30	50	81
1975	48	38	25	33	46	80
1976	44	33	26	29	41	62
1977	45	33	25	27	41	81
1978	49	38	27	31	46	75
1979	54	41	27	39	51	29
1980	63	49	31	44	55	108
1981	69	55	36	47	75	90
1982	64	54	38	42	73	88
1983	67	56	46	47	67	94
1984	63	52	36	41	63	98
1985	56	48	32	35	54	85

Table 16

KEY STATISTICS: OPERATING COST PER OUNCE OF GOLD PRODUCED ($ 1985)

YEAR	KEY STATISTICS BY AMOUNT OF GOLD					
	MEAN	MEDIAN	LOWER DECILE	LOWER QUARTILLE	UPPER QUARTILE	UPPER DECILE
1946	204	196	137	167	219	278
1947	190	178	128	152	209	245
1948	179	166	134	145	196	234
1949	173	162	99	141	186	218
1950	165	163	98	139	179	216
1951	152	153	88	131	167	197
1952	144	147	73	132	155	190
1953	141	141	88	117	159	176
1954	142	142	88	123	161	180
1955	135	134	77	106	153	181
1956	130	135	73	97	147	181
1957	128	129	72	97	149	178
1958	124	132	76	96	145	165
1959	125	132	72	81	151	168
1960	124	132	73	82	152	166
1961	128	132	84	89	154	170
1962	133	143	76	93	159	182
1963	132	136	79	99	158	166
1964	135	141	67	107	150	185
1965	134	137	78	105	161	184
1966	135	143	83	92	157	178
1967	134	143	72	97	159	173
1968	135	137	67	119	155	169
1969	140	141	65	113	162	180
1970	134	135	67	105	156	179
1971	128	134	62	107	149	167
1972	132	128	63	97	167	179
1973	159	160	62	90	203	220
1974	197	182	71	121	256	292
1975	220	200	86	147	265	304
1976	201	200	92	126	231	300
1977	202	194	93	140	265	279
1978	232	236	108	164	282	315
1979	268	253	111	152	333	396
1980	351	312	123	222	501	601
1981	388	367	130	238	553	673
1982	333	339	129	229	407	487
1983	350	331	127	302	375	456
1984	335	305	138	264	425	478
1985	301	289	138	225	361	403

APPENDIX III

ILLUSTRATIVE EGMA PAYMENT CALCULATION

The following gold mine example is used to illustrate the calculation of EGMA payments in current dollars for the terms outlined in table 4.

"Base year" production: 45,000 ounces

Production in present year: 48,000 ounces

Costs per ounce: $44.00

Original 1948 Terms

Rate of Assistance = .50(44.00-18.00) = $13.00 per ounce
Eligible Ounces
1/3 annual production = 48,000/3 = 16,000 ounces
48,000 - 2/3(45,000) = 18,000 ounces
Eligible Ounces = 18,000
EGMA Payment = (13.00)(18,000) = $234,000
Assistance per Ounce = 234,000/48,000 = $4.87

1950 Terms

Rate of Assistance = $12.50 per ounce (maximum allowable is less than $13.00 per ounce rate calculated)
Eligible Ounces = 18,000
EGMA Payment = (12.50)(18,000) = $225,000
Assistance per Ounce = 225,000/48,000 = $4.69

1951 Terms

Rate of Assistance = .50(44.00-22.00) = $11.00 per ounce
Eligible Ounces = 1/2(48,000) = 24,000
EGMA Payment = (11.00)(24,000) = $264,000
Assistance per Ounce = 264,000/48,000 = $5.50

1953 Terms

Rate of Assistance = .50(44.00-18.00) = $13.00 per ounce
Eligible Ounces = 48,000 - 1/2(45,000) = 25,500
EGMA Payment = (13.00)(25,500) = $331,500
Assistance per Ounce = 331,000/48,000 = $6.91

1955 Terms

Rate of Assistance = 2/3(44.00-26.50) = $11.67 per ounce
Eligible Ounces = 32,000
EGMA Payment = (11.67)(32,000) = $373,440
Assistance per Ounce = 373,400/48,000 = $7.78

1958 Terms

EGMA Payment = 1.25(11.67)(32,000) = $466,800
Eligible Ounces = 32,000
Rate of Assistance = $11.67 per ounce
Assistance per Ounce = 466,800/48,000 = $9.73

Summary

EGMA Terms	EGMA Payment ($)	Assistance per Ounce ($)
1948	234,000	4.87
1950	225,000	4.69
1951	264,000	5.50
1953	331,500	6.91
1955	373,440	7.78
1958	466,800	9.73

APPENDIX IV

CLASSIFICATION OF 169 GOLD MINES INCLUDED IN STUDY DATA BASE BY DYNAMIC COMPONENT

Short-Term Sources of Supply: Existing Gold Mines Which had Produced Prior to 1946

Nova Scotia[13]

Quebec

BELLETERRE
CANADIAN MALARTIC
CONSOLIDATED BEATTIE
CONSOLIDATED CENTRAL CADILLAC
EAST MALARTIC
ELDER
FRANCOEUR
LAMAQUE
LOUVICOURT
MALARTIC GOLDFIELDS
MICMAC
O'BRIEN
POWELL
SENATOR ROUYN
SIGMA
SISCOE
SLADEN
STADACONA
SULLIVAN
WASAMAC
WEST MALARTIC

Ontario

AUNOR
BIDGOOD KIRKLAND
BONETAL
BROULAN
BUFFALO ANKERITE
CENTRAL PATRICIA
CHESTERVILLE
COCHENOUR WILLANS
CONIAURUM
DELNITE
DOME
HALLNOR
HARD ROCK
HASAGA
HOLLINGER
HOYLE
JASON
JELLICOE
KERR ADDISON
KIRKLAND
LAKESHORE
LEITCH
LITTLE LONG LAC
MACASSA
MACLEOD COCKSHUTT
MADSEN
MAGNET
MATACHEWAN CONSOLIDATED
MAYLAC
MCINTYRE
MACKENZIE RED LAKE
MCMARMAC RED LAKE
OMEGA
PAMOUR
PAN EMPIRE
PAYMASTER
PERRON
PICKLE CROW
PRESTON
ROSS
SYLVANITE
TALMORA
TECK HUGHES
THERESA
TOBURN
UPPER CANADA
WRIGHT HARGREAVES
YOUNG DAVIDSON

13. Provincial total not disaggregated by deposit.

Manitoba

SAN ANTONIO

Northwest Territories

CON/RYCON
NEGUS
RUTH
THOMPSON LUNDMARK

British Columbia

ALPINE
BRALORNE
CARIBOO
HEDLEY
ISLAND MOUNTAIN
KELOWNA
KENVILLE
KOOTENAY BELLE
PIONEER
POLARIS
PRIVATEER
SHEEP CREEK
ZEBALLOS

Yukon Territory

LAFORMA

Medium-Term Sources of Supply: Gold Deposits Discovered Prior to 1946 and Brought Into Production During 1946-85 Period

Quebec

AKASABA
ANGLO ROUYN
BARNAT
BEVCON
CONSOLIDATED DUQUESNE
DONALDA
ELDRICH
HEVA
HOSCO
NEW MARLON
NEW ROUYN
NORBEAU
NORLARTIC
QUESABE

Ontario

AQUARIUS
CAMPBELL RED LAKE
DICKENSON
GOLDLUND
MCBEAN
MOSHER
RENABIE
ROBIN RED LAKE
STARRATT OLSEN

Manitoba

FORTY FOUR
NORACME
OGAMA

British Columbia

KOOTENAY CENTRAL
MOSQUITO CREEK
PRIVATEER
SCOTTIE

Northwest Territories

DISCOVERY
CAMLAREN
GIANT
SUPERCREST

Long-Term Sources of Supply: Gold Deposits Discovered and Brought Into Production During 1946-85 Period

Quebec

AGNICO
BACHELOR LAKE
BELMORAL
BOUSQUET
CAMFLO
CHADBOURNE
CHIMO
DESTOR
DOYON
GWILLIM LAKE
KIENA
LAC SHORTT
MALARTIC HYGRADE
MARBAN
MUSCOCHO

Ontario

ANNCO
BONWHIT
CORONA
DETOUR LAKE
GAIL
GOLDEN GIANT
H.G. YOUNG
HOYLE POND
HUGH PAM
JOBURKE
LOUANNA
OWL CREEK
ROBIN RED LAKE
SAPAWE
STAIRS
WESTFIELD
WILLIAMS
WILMAR

Manitoba

JEEP

British Columbia

BAKER
CAROLIN
ERICKSON
FRENCH
TAURUS

Northwest Territories

CULLATON
LOLOR
LUPIN
SALMITA
TUNDRA
VOL

Yukon Territory

ARCTIC GOLD

THE AUTHORS

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